Tc ph
E

THE

JOURNAL

OF THE

Franklin Institute,

111

DEVOTED TO

Science and the Mechanic Arts.

EDITED BY

PROF. HENRY MORTON, PH.D.,

ASSISTED BY THE COMMITTEE ON PUBLICATIONS.

Vol. LXXXIII.—No. 493.

THIRD SERIES.

VOL. LIII.—JANUARY, 1867.

PHILADELPHIA:

PUBLISHED BY THE FRANKLIN INSTITUTE AT THEIR HALL.

1867.

INDEX.

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. LIII.] JANUARY, 1867. [No. 1.

Editorial.

The Editor and the Committee on Publications take occasion, at this time, to announce to the readers of the *Journal* certain changes, which it is their purpose to make in the conduct of this publication, and in which they hope for general co-operation and approval.

They propose, in the first place, to make every effort to secure such original matter, descriptive of important engineering works, as shall be of direct and evident value to practical engineers, preferring, in this respect, accurate and full descriptions of constructive details as actually executed, to theoretical discussions and mathematical investigations of general principles, which, however excellent of their kind, are of less direct interest to the working engineer, who is, as a rule, unable to bestow the time and attention necessary to eliminate an useful result from such studies. In pursuance of this plan, they have secured, and propose to publish in this and succeeding numbers, in addition to other matter of a similar kind, a very full description of the bridge, just finished, over the Susquehanna, at Havre de Grace, designed by George A. Parker, C. E., and constructed under his immediate supervision. This will be fully illustrated with elaborate working drawings, measurements, and every detail. In the second place, they propose to increase the proportion of original matter in the *Journal*, and to effect this, without detriment to the fund of

valuable information which has been heretofore reprinted from foreign magazines, by substituting carefully prepared abstracts of such articles as may be in this way faithfully rendered, for the entire papers as originally published, giving, in all cases, reference to the authority to which those desiring fuller information, may resort.

Again: they will offer every inducement to our mechanical constructors and inventors, by which they may be led to use the pages of this *Journal* as a means of publishing their inventions, and securing the attention of those most interested in such works. Lastly: for the promotion of that elementary knowledge on general scientific subjects, which is daily becoming more important to the successful prosecution of all arts, they propose to add to this *Journal* an Educational Department, in which the various sciences shall be, from time to time, treated in a simple, popular and practical manner, with very full illustration, and every attention to the earliest possible notice of all new facts and discoveries.

In the execution of the above-mentioned designs, the managers of this *Journal* confidently look for the co-operation of all who feel an interest in the advance of science and the arts in this country.

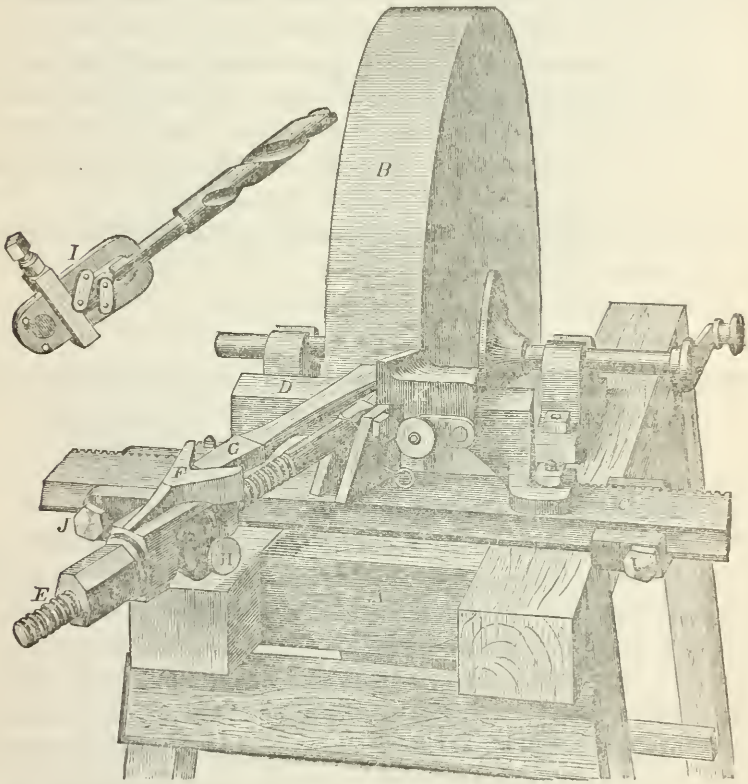
While in England and the Continent, Journals devoted to the interests of the civil and mechanical engineer, may be numbered by the tens, we might almost say hundreds, in this country, the *Journal of the Franklin Institute* stands alone. To it, must our engineers and machinists look for a just and impartial record of their works, which, circulated largely by reason of its exchanges throughout the world, may secure for them that extended reputation, which is the legitimate object of the most honorable ambition. By its means also, they may put on record, and thus preserve to future times and for the instruction of others, those experiences which otherwise perish with themselves, and leave the world but little benefited by their labors. To it they must look, again, for a medium by which a general exchange of ideas may be effected, and an opportunity offered for that free discussion so effective in the promotion of all progress and improvement.

In view of these and other like considerations, our engineers, manufacturers and machinists, should make common cause with us, and by aiding us, on the one hand, in obtaining early and full information on all topics in their departments and within their reach, and, on the other, by favoring the extended circulation of our publication, should strive to make this *Journal*, what we hope to see it, a creditable exponent and record of engineering, science and the mechanic arts in America.

Civil and Mechanical Engineering.

STRAHAN'S DRILL REST FOR GRINDING.

All of our readers who are interested in such matters, will be well aware of the difficulties which attend the grinding of a drill, in such a manner as to make both of its cutting edges exactly alike in angle and position, and of the necessity which exists for such equality.



Such grinding, difficult as it is with ordinary drills, becomes yet more so with twist-drills, which are now obtaining so large a popularity. It is, therefore, with great pleasure that we record the invention of the ingenious tool named above, by which all difficulty is avoided, an absolutely correct shape is secured, and the whole operation is reduced to the simplest form; so that no skill or experience is required for its successful execution.

The tool, as applied to the grindstone with the drill in its place, is shown in the accompanying cut.

To the frame of the grindstone, B, is attached the bed-plate, C, by means of the jaws, J J. This bed-plate carries a rest, D, with guide-block, K, to which is attached a pivoted screw, E, capable of vertical adjustment by means of a projection on its pivoted end, which is held in the position desired by a pin. This pivoted screw carries a sliding thrust-block, F, which is moved up by the nut shown at E.

The drill to be ground is supported on the rest, D, against the guide-block, K, with its heel in the thrust-block, F, and is gradually pressed forward by the nut, until sufficiently ground on one edge; a stopper, H, is then set at this point, the nut and thrust-block are run back, the drill is turned, and its other edge ground as before, until the thrust-block is arrested by the stopper, when the operation is complete.

For grinding twist-drills, a little vise is used, (shown at I,) whose centre always corresponds with that of its jaws.

The above arrangement was patented, October 2d, 1866, by Wm. H. Strahan, of Philadelphia.

THE SUSQUEHANNA BRIDGE ON THE PHILADELPHIA, WILMINGTON AND BALTIMORE RAILROAD.

Designed by George A. Parker, C. E.

PRELIMINARY NOTICE.

This bridge, of which a very full description will be hereafter published, commends itself to our attention chiefly, and beyond all other respects, by reason of the peculiar method employed in the erection of its substructure, and the special conditions which rendered this method so desirable and efficient. These conditions are now found to be repeated in many of our Western rivers, the bridging of which is one of the immediate problems in practical engineering, and the history of what has been done in this case thus acquires a peculiar and momentous interest.

A brief historical notice of this work and a general account of its prominent features may well preface the more detailed description of its structure, which we propose to develop.

As early as 1851, Mr. S. M. Felton, President of the Philadelphia, Wilmington and Baltimore Railroad, called upon the engineer of this bridge for his opinion on the subject of such a structure.

Some preliminary work was then executed, but financial difficulties led to the temporary abandonment of the enterprise.

In the summer of 1862, however, a more prosperous state of affairs warranted the resumption of the work.

The engineer was instructed to prepare plans for a structure, and to build one pier, which should be a test as to the practicability of the work. On the 15th day of September, of that year, the foundations of the third pier from the east bank of the river were commenced, and finished October 2d; that is, the foundation piles, numbering one hundred and fifty, were driven and sawed off to a uniform surface at a level of forty feet below the water.

The lateness of the season forbade continuing the work, and it was determined, therefore, to attempt the construction of the fourth pier, that pier being in shallow water, at a depth of about ten feet. The work of constructing it, it was thought, might be completed before the winter's floods. Operations were commenced October 15th. About one hundred foundation piles were driven and sawed off, ten feet under water, in four hours.

On the 28th of October the masonry of that pier was completed to the height of eight feet above low water. The following winter and spring were mild and subjected it to a less satisfactory test than was desired. Nevertheless, it was resolved to continue the work on the other piers, as the importance of the bridge became greatly enhanced owing to the existence of the Rebellion.

Accordingly, in the spring of 1863, pier No. 3 was examined by divers, and found to be covered by deposits of alluvium, varying from five feet to eighteen inches. By application of powerful pumps, aided by the skillful labors of divers, the deposit was removed in less than three days.

Additional piles were driven and sawed off by these divers at the level of the other piles, forty feet below the surface, and on the 24th of August the platform of timber and iron upon which the pier was to rest, was floated out over the site of foundation, and placed between two substantial construction-piers of timber.

Lowering screws, six in number, three and a half inches in diameter, were then attached to the platform and the construction-pier, and the first section of the boiler plate iron caisson, in which the masonry of the pier was to be built, was erected.

These screws were attached to the platform in such a way that they could be easily detached by the divers, after the platform was in place on the heads of the piles already mentioned (which had been sawed off forty feet under water), and worked through nuts which were attached to the construction-piers.

On the 24th of September of the same year, the masonry within the caisson was commenced, and the work went steadily on with the descent of the pier until two o'clock of the afternoon of November 9th, when suddenly one of the attachments of the screws to the platform gave way, the result of using imperfect material, and the pier careened to the west side of the pile inclosure.

The bottom of the platform was then within seven feet of the foundation-pile. The weight upon the screws was, perhaps, one hundred and forty tons. The caisson was still almost perfectly water-tight, and, supported as it was by the construction-piers, was entirely manageable.

Two courses of stone were immediately removed from the pier, the screws on the eastern side were turned off, and on the 11th of November the pier righted again, and at noon of the 15th it was finally landed upon the foundations. On December 18th, the masonry was completed to a height of about twelve feet above high water.

Some additional work was then done on pier 4, and work was commenced on the foundations of piers 5, 6 and 7. It was, however, soon discontinued for the season. In the following spring of 1864, work was recommenced on piers 5 and 6, and upon the foundations of pier 7. In April, the foundations of the eastern abutment were commenced, and during the year, the masonry was carried to the height of fourteen feet above low water.

During this year the greater part of the foundation of pier 1 was completed; pier 2 finished to the height of twelve feet above low water; pier 5 was entirely finished, and pier 6 was completed to the top of the coping. In the season of 1865 the eastern abutment was substantially completed, and piers 1 and 2 were nearly finished.

In the spring of this year it was found that the unusually severe freshet had made great changes about the foundation of pier 7. In several places fifteen feet of earth had been displaced, and it was deemed necessary to remove all the earth from the rock at that point, and to found the pier upon the rock bed, lying eighteen feet below the original bed of the river.

The work of removing this earth was one of great seeming difficulty. A wrought iron foundation caisson, averaging eight feet in height and about fifty by twenty feet square, was lowered so as to inclose the site of the pier. This was gradually depressed to the rock by removing the earth within it, by means mainly of powerful pumps, aided by the constant exertions of six skillful divers. The masonry was then laid within the tank, upon the solid rock, and brought to a level some feet below the top of the foundation caisson.

Upon that, the caisson of the pier resting upon the platform of timber, was lowered. This pier was completed on the 3d of December. Its foundation was thirty-six feet below low water. The foundations of pier 9 were commenced on the 2d of May, 1865, and finished September 27th. The masonry of that pier was completed October 23d; depth of water, thirty feet. Piers 12 and 13 were finished, and the masonry of the western abutment was brought to a safe height above low water, and before the 2d of that year three spans of the superstructure were erected.

In the present year, 1866, piers 7 and 8 were completed, and the foundation of pier 10, begun May 25th, was finished July 7th. Foundations of pier 11 were begun April 11th and finished June 19th. The western abutment was finished on the 15th of September. The guard and piers for the draw were commenced on the 9th of September, and are now nearly finished, thus completing the masonry connected with the bridge. July 25th, of this year, all but three of the thirteen spans of the superstructure were raised upon the piers, though not completed.

On that day a terrible tornado took place, which overthrew the whole superstructure then erected, except one span and the lower timbers of another. On the evening of that day, preparations were made for gathering together the wrecks of the prostrated bridge. On August 3d the rebuilding of the same was commenced, and on the 7th of November, *eighty-six working days from the time of commencement*, an engine passed over the two first spans.

On the 20th of November an engine passed entirely across the bridge. On this present day, November 26th, 1866, the bridge, though not entirely finished in all respects, is open to public travel. For five years from five hundred to one thousand men have been employed upon this great work. Upon its construction nearly five million feet of timber, twenty thousand cubic yards of masonry, three million pounds of wrought and cast iron have been used.

The structure between the shores of the river is about three thousand five hundred feet in length. It has thirteen supporting piers and two guard piers at the draw, and two abutments. The piers are built in water varying from ten to forty-five feet in depth. The spans are two hundred and fifty feet in length between bearings. The draw span is one hundred and seventy-six feet long. Height of superstructure twenty-five feet.

The superstructure is an improved form of the Howe truss. When completed each truss is to be encased entirely in iron, thus making it fire-proof and free from exposure to the weather. The peculiarity of the hydraulic engineering connected with this work is the disuse of the Coffer dam.

Instead thereof water-tight wrought iron caissons have been used.

The whole cost of the magnificent structure has been something less than $2,000,000.

The bridge is approached from the main road on the east side by a track laid over heavy trestle-work, fourteen hundred feet long. This trestle-work is but temporary, and, as soon as practicable, will be replaced by an earth embankment, supported by retaining walls of appropriate masonry. At the end of this is a firm abutment of strong masonry, handsomely constructed of granite from the quarries in the vicinity of Port Deposit, only six miles from the structure. This granite is of dark color, of elegant appearance when worked, and is said to be the hardest and heaviest in the world—heavier by three pounds to the cubic foot than that of the famous Egyptian Pyramids. There are one of these abutments in each end, similarly constructed.

The bridge is secured to the piers by means of bolts, three inches in diameter, which pass through holes drilled for that purpose to near the surface of the water, where they are, by means of a ring at the end, attached to a similar horizontal bar that passes through the sides of the pier. The upper ends of these perpendicular bars pass through a heavy oak bolster, and are fastened with a nut at the top, by means of the screw, upon which they can be tightened if occasion should require.

The timber of this structure has been very carefully selected. It has also gone through the process of Burnettizing, by which its durability is not only increased at least two-fold, but by which it is rendered indestructible by fire. This treatment was applied by Mr. Charles P. Bent, who has an establishment for the purpose at Perryville, and several others upon railroads in different States.

This process is familiar to our readers, and consists in removing air &c. from the fibres of the wood, by placing it in an exhausted vessel and then injecting chloride of zinc.

The timbers of the bridge are secured by means of iron bars and butt seats. These bars are about twenty-five feet long, and vary in thickness from one to three inches, the largest weighing seven hundred pounds. In the construction of the bridge nearly seventeen hundred of these bars are used. The immense weight of the structure may be estimated from the fact that there is used upon each span about two hundred tons of wood and iron. Iron is much more extensively used than is common in timber structures. As an instance, the bottom chords, where most exposed to a tensile strain, are entirely sheathed on the sides with plate iron three-eighths of an inch thick.

THE NEW YORK "CENTRAL PARK."

By William H. Grant, Superintending Engineer.

INTRODUCTORY REMARKS.

The New York Central Park, now nearly completed, has grown up under steady and uninterrupted progress during the last few years—passing through a most eventful and trying period, financially and otherwise—into a great municipal work, that presents at this time to the liberal and enlightened citizens of New York, who have created it, its elevating and invigorating influences, with a promise of constantly expanding attractions and benefits, as nature, assisted by the hand of art, is permitted, in her own inimitable ways, to perfect the work that has thus far been accomplished. It is a new work of its kind in this country. In its design and execution it has developed and practically applied the combined problems of civil engineering and landscape gardening, on a larger scale, and in a much greater variety of forms, than has heretofore occurred among us. As a pioneer improvement of this character, taking the lead of, and directing the way for, a series of similar works that the advancing wave of intelligence and wealth is soon to spread widely over the country—it has a value that surpasses even its local worth (great as that is) to its fortunate possessors.

It is only about eight years since the first spade was put in the ground, the first drill driven in the rock, and the example has been followed by several neighboring cities, as Baltimore, Philadelphia, Brooklyn &c., in the laying out of public parks, some of which are well advanced; other parks are contemplated, not only by well-grown cities, but by thriving villages, cities in embryo. An impulse has also been given to individual as well as municipal enterprise, as evidenced in the rural improvements that are beginning to be made, on a liberal scale, by men of wealth, and by an increasing desire that is manifested by persons of more limited means for the tasteful adornment of their residences.

The Central Park has become the resort of those several classes of persons who seek here for examples and hints to serve their respective purposes. Some come to scan the design as a whole—to take in its entire scope—and form in their minds ideas as to its adaptation to some other locality of similar extent; some select a more limited space, and study its suggestions and special mode of treatment to meet their particular views; others give their attention to such separate classes of

work only as they may have occasion to reproduce; and others again seek only a single specialty, to learn from it how to supply a want of that kind. A wide and diversified field is presented for pursuing these investigations, and few fail to cull from it ideas that are available, to a greater or less extent, according to the taste and discernment they respectively possess; their views are enlarged and perceptions quickened upon a range of subjects of utility and beauty, and much good grows out of it. But, after all, it must be felt by each person in the pursuit of this kind of knowledge, in this way, that he labors under difficulties that it would be desirable to remove, an acquaintance with the principles upon which the whole, or any part, of the work is based, is wanted. A fair surface is presented to the eye, and all is agreeable and attractive, but the foundation of the structure is concealed, and without some knowledge of this—although a superficial copy may be made—the whole is liable to fail, and prove an unsubstantial and "baseless fabric of a vision."

In order to meet a want of this kind, and supply some practical aids to those who wish to apply judiciously both the principles and practice that have governed the execution of the work, is the object of the following pages.

It is scarcely necessary to premise further, that the work of the Park, from its novelty and the inexperience that prevailed at its commencement, has had to be studied out step by step in all its departments and details—from the outline plan of a portion of the work that was adopted as a basis to start from, down to its present nearly completed condition. It would have been of great service to all who have participated in the work if they could have referred directly to examples and data to meet the various cases as they arose, even the most trivial ones, and would have saved them the expenditure of much mental labor and anxiety.

When this is remembered, it is not doubted that the description of the practices and processes that is here given will prove of service to others who may have occasion to reproduce similar works. Some things may appear in the recital, simple, and even trite—they appear so *now* to the writer—but it has not been considered advisable to pass them by, in the general connection, on that account. Brevity has been studied as far as reasonable clearness would allow; and it has been the aim to mass together facts and matters of interest, rather than to make the subject what may be called, popularly readable. Upon these points and accuracy of description alone the writer expects to escape criticism. The circumstances under which these pages

have been put together have not been favorable to any other endeavor than this. If the substance should be found of practical value, the reader will leniently overlook the imperfections of form or medium through which it is presented. Should these desirable results occur, I might say, in customary phrase, that the object of the writer will be fully attained; this, however, would not be strictly correct, for I have had an additional incentive in the undertaking—that of contributing a testimonial to the Engineer Corps by whom I have been aided, and to whom a large share of the credit is due for the successful execution of the works of the Park. Few persons are aware of the unwearied vigilance, the close and exact attention and skill, that have been exercised by these gentlemen in the course of the long service these works have required. It is with great pleasure that I make this the occasion—I hope the reader will think not inappropriately—to render to them the best acknowledgment in my power, not only for their professional aid, but for their social companionship, through the several years' journey—not always over ground that was free from asperities—that we have made together.

It is not my province to speak in commendation of the Board of Commissioners, under whose administration this work has been carried forward; but in so far as they have permitted those to whom they have entrusted its execution, to conduct it, free from the absorbing and evil influences of politics, I cannot refrain from expressing my individual gratitude and admiration. In this respect, the Central Park has been exceptional to most of the public works that have been executed under our municipal or state authorities. Its continued success will be dependent, even in a greater degree than heretofore, upon the maintenance of the policy that has been thus wisely inaugurated. Personally, I should feel it a misfortune to see this costly and beautiful work thrown into the arena of politics. I should expect, in such an event, to see the works upon which months and years of study and care have been expended, neglected, misunderstood and perverted, a loose and disorderly management dispelling the feeling of security and quiet that is essential to the enjoyment of all visitors, and a rapid deterioration of the Park from all the objects for which it was designed. Such results every good citizen—every person, of whatever degree, to whom the privilege is extended, and it is extended to all, to enjoy this healthful pleasure ground—must deprecate. Difficult as it may be (and there are difficulties) to exclude political influences, it must nevertheless be done, not alone in appearances, covering over an insidious and deleterious under-current, invisible for the time to the public eye, but in

all honesty and fidelity. As a work of art, the first that has arisen among us of its kind, it is doubtless to be subjected to a severe test; its management is a serious experiment: if it goes wrong, it will be fatal; if right, the blessings of multitudes of pent-up men, women and children will attend it.

The class of works of the Park that the public have manifested the earliest interest in, and from which they have thus far realized the largest benefit, is that of *roads and walks;* these have preceded most other improvements in the order of construction, and will doubtless meet, in their practical application, if found adapted to the object, the largest range of public and individual every-day wants. They have consequently been selected as the first subject to occupy attention.

As the subject of landscape design would naturally be expected to take precedence of works of construction, it is proper to say that the design of the Park, as a whole, as now nearly worked out, was progressive, was the work of several different persons at different times, and was not completed much in advance of actual construction; and therefore is deferred to the close of other details. In that place it will be considered more comprehensively, in its origin, history, adaptation &c.

HEATING AND VENTILATION OF THE PHILADELPHIA ALMSHOUSE.

Extract from the Report of the Committee, JOHN M. WHITALL, Chairman.

THE VENTILATION.

WHEN your Committee was appointed, all parts of the Almshouse were imperfectly ventilated—the Hospital and Insane Departments by connections with a large chimney in each, but which we found nearly or quite useless for the purposes intended, and the alterations necessary to be made in removing the boilers from the building required the plan of ventilation to be entirely changed. In other departments there was no ventilation, excepting by the doors or windows, with the exception of an occasional fire-place in some of the wards. As the warm air was introduced into the different apartments by our improvements, an independent flue for ventilation was erected in each, extending through the roof, and thus the egress of foul air could not be interfered with by connection with other wards. This has been found to be a very important condition. In these, flues

in the Hospital, openings near the ceiling and near the floor, were made, with a register in each. In using them, it was soon discovered that if the floor openings were closed and the ceiling registers opened, the wards became foul and the temperature lower. On the contrary, by closing the apertures near the ceiling and opening the registers near the floor, the thermometer at once indicated increased warmth, and the wards were directly cleared of all offensive odor. This ex-experiment having been fully tested, and always with the same result, the use of the upper ventilator was entirely dispensed with. In all other parts of the Almshouse the same general plan has been followed. In those wards which are heated by direct radiation from steam-pipes or stoves, openings near the floor have been made into flues, extending through the roof, so that the Nurseries, Out-wards &c. are at all times free from any unpleasant effluvium.

THE CHOLERA.

Your Committee beg leave to call your attention to the breaking out of cholera at the Almshouse in the present year, and to the apparent effect, under the blessing of a kind Providence, produced by thorough ventilation from the floor, in its prevention and final disappearance from the Institution. The disease first attacked four patients and a nurse in one of the wards of the Women's Hospital, which ward, upon close examination, was found to be imperfectly ventilated. This was at once remedied, after which there were no more cases in the Hospital.

In the Insane Department for females, the cholera occurred in several of the wards; these were ventilated by the old plan, from the ceiling or by windows and doors, as the ventilation in this Department was not yet perfected, but on the appearance of the disease strong efforts were immediately made to push it forward, and it is a remarkable fact, that as soon as a thorough ventilation from the floor was established, the cholera disappeared from the Institution. It may be proper here to remark, that heat was introduced into the wards about two hours, daily, during the prevalence of the disease, and it is also worthy of note that in no part of the Almshouse, although crowded, was there any cholera where the ventilation from the floor was thoroughly perfected. And we would further state, that since it has been fully established, no case of fever or dysentery, and very few of erysipelas or gangrene, have originated in the Hospital, or any part of the House. And those patients brought in from the city with these diseases, mostly soon recovered, and the health of the inmates is at this time excellent.

Your Committee believe that the ventilation of the Almshouse, in all the wards, is so perfect that rarely any hospital smell or offensive odor can be perceived in passing through. (See Secretary's Report.)

From the London Engineering, No. 44.

THE METROPOLITAN DISTRICT RAILWAY.

THE present Metropolitan Railway, extending from Bishop's Road to Moorgate Street, forms, as is very generally known, but the northern side of an irregular "circle" of underground railways which will surround that part of the metropolis lying between the existing line and the Thames. Of this "inner circle," as it is called, the Metropolitan District Railway will form the southern side, whilst the eastern and western portions will be formed by extensions of the Metropolitan Railway, acts for the construction of these additional lines, of which Mr. John Fowler and Mr. T. Marr Johnson are the joint engineers, having been obtained in 1864.

By examining the routes, both constructed and proposed, for the Metropolitan District and the Metropolitan Extension Railways, it will be seen that, at the eastern end, the extension of the Metropolitan Railway is to be carried under Bishopsgate Street, near Houndsditch, and that it will then curve to the south, extending, under Aldgate High Street and the Mineries, to Trinity Square. At Trinity Square the Metropolitan District Railway will commence, and from this point it will proceed nearly parallel to the river until it cuts the line of the new street which is to be constructed from Blackfriar's Bridge to the Mansion House. Following the line of this street, the railway will reach the river at Blackfriars, and will then be carried along the embankment to within a short distance of Westminster Bridge. At this point the line will leave the river side, and, curving to the west, will proceed past Westminster Abbey, under Tothill Street, and along the northern side of Victoria Street, to the Victoria Station. Beyond this station the railway will bend round to the south, and, after passing for a short distance between Ebury Street and Belgrave Place, it will again turn to the west to Sloane Square. From Sloane Square the line will follow an almost straight course to Cromwell Road, where it will join the western extension of the Metropolitan Railway. From Cromwell Road the western extension of the Metropolitan line will curve to the north, and will proceed in a north-westerly direction to Kensington Terrace, Notting Hill, where it will curve to the east, and eventually join the existing line at Edgeware Road.

The Metropolitan District Railway includes, beside the line of which we have described the course, two branch lines connecting the "inner circle" with the West London Railway. One of these branches will

commence at Cromwell Road station, and, after proceeding side by side with the "inner circle" line, to a short distance beyond the Gloucester Road, will turn to the south-west through Earl's Court to a junction with the West London line near Richmond Road. The other branch will leave the western side of the West London Railway, further north, and will then curve to the east, pass under the West London line, and run through Earl's Court, by the side of the branch first mentioned, to a short distance past Redfield Lane, where it will bend to the north, and will be carried side by side with the inner circle line to Kensington station.

The station accommodation which will be provided on the new lines will be as follows: On the eastern extension of the Metropolitan line there will be a station at Bishopsgate Street, and another near Aldgate, whilst at Trinity Square there will be a joint station for the extension of the District railways, this station forming an exchange station with the London and Blackwall Railway. On the Metropolitan District Railway proper there will be stations at Mark Lane, King William Street, and at Queen Street (Cannon Street); and at Blackfriars there will be an exchange station with the London, Chatham and Dover Railway. There will also be a station at Norfolk Street; and at Charing Cross there will be an exchange station with the South-Eastern line. The next station will be at Westminster Bridge, and then will come the St. James' Park and Victoria stations, the former of which will be situated close to Queen's Square Place, and the latter adjoining the present station of the same name, so that it will form an exchange station with the London, Chatham and Dover, and London, Brighton and South Coast Railways. The next stations in order will be those at Sloane Square and Cromwell Road, whilst there will also be stations, used jointly by the Metropolitan District and Metropolitan Railway proper, at Gloucester Road and Kensington, and another at Richmond road, for the joint use of the Metropolitan District and West London Railways. The Cromwell Road and Kensington stations will be exchange stations for the traffic to the West London Railway and its connections. On the western extension of the Metropolitan line there will be, in addition to the two joint stations already mentioned, other stations at Notting Hill, Bayswater and Paddington. The last station will be situated opposite the Paddington Hotel, and will be connected with the Great Western station by underground passages; it will be quite distinct from the existing Bishop's Road station.

The total length of the Metropolitan District Railway, from Tower Hill to the Richmond Road, is about six miles, and of this length one-half will be level. Of the remaining portion, about a quarter of a mile will be on a gradient of 1 in 300, more than half a mile will be 1 in 250, three-quarters of a mile 1 in 200, and about half a mile 1 in 100, whilst the rest will be made up of gradients rather less steep than 1 in 100. The greatest difference between the levels of the rails at any two points is $37\frac{3}{4}$ feet, and the three lowest points are under the Ranelagh, Fulham Road and King's Scholars' Pond sewers, respect-

ively, the rail-level of the latter point, which is the lowest of all, being 9 feet 3 inches below ordnance datum, or 21 feet 9 inches below Trinity high water. The sharpest curve is one of 10 chains radius near the Victoria station; the remaining curves have radii of 15, 20, and 30 chains and upwards.

Having given a general account of the course and extent of the Metropolitan District Railway, we shall now proceed to describe more in detail the principal works connected with it, so far as they are at present executed or in progress. Between Trinity Square and Westminster Bridge, the only portions which have been executed are two short lengths, one in front of the Cannon Street station of the South-Eastern Railway and the other under the London, Chatham and Dover Railway, at Blackfriars. The piece at Cannon Street is 225 feet in length, and is covered by wrought iron girders bent downwards at the ends, so that they have a shape resembling the outline of a Mansard roof. On these girders are erected brick walls, and between these are turned arches, upon which the superincumbent earth and road-metalling is carried. The object of this mode of construction was to lessen the thickness of earth &c. above the girders, and thus reduce, as far as possible, the load upon them.

At Westminster, the first length of the works in hand commences close to New Palace Yard, and extends to the eastern end of Victoria Street. For this length, the line will be carried in girder-covered way, the roofing being formed of cast iron girders, with intermediate brick arches. Under Parliament Square Gardens, the side walls are being constructed with 6 feet bays, measured from centre to centre of the counterforts; and the girders are 6 feet apart, and 1 foot 6 inches deep in the centre. Nearer Bridge Street, however, the walls are being made with 8 feet bays, the girders being 2 feet 6 inches deep in the centre, and this is the ordinary construction of girder-covered way along the line. The girders have top flanges 7 inches $\times 1\frac{3}{4}$ inch, and bottom flanges 20 inches by $2\frac{1}{4}$ inches, and the web is $2\frac{1}{4}$ inches thick at the top and 2 inches at the bottom, whilst the distance between the walls or span of the girders is 25 feet. The girders are furnished with cross flanges, projecting downwards 6 inches from the underside, which bear against the inner sides of the side walls and thus strut them apart. The brick arches between the girders are three rings thick, and the spandrils are filled in with concrete, over which is a layer of asphalte, $\frac{3}{4}$-inch thick, this being put on in two coats of $\frac{3}{8}$-inch each. Upon the asphalte there is laid under the streets 1 foot of road-metalling. The clear height of the undersides of the girders above rail-level is 13 feet 6 inches.

The counterforts of the side walls are 5 feet 6 inches deep horizontally for their whole height, being built without batter; whilst their thickness is three bricks in front of, and two bricks behind, the arched panels. The panels are formed of three rings of brickwork, and are built with a batter. The walls are founded on concrete carried 5 feet below rail-level, and the panels are also backed with concrete to the

level of the backs of the counterforts, each bay being provided with a 4-inch pipe packed around with gravel for the purposes of drainage. An 18-inch barrel-drain is also carried down the centre of the line at a variable distance below the rail-level, and from Blackfriar's Bridge to Gloucester Road the excavation will be provided with a concrete invert 2 feet 6 inches thick.

The manner in which the construction of the covered way is carried out is as follows: Two trenches are excavated at the proper distance apart to receive the side walls, and the space between them is, where necessary, lowered to make room for the girder covering. The sides of the trenches are, of course, supported by the usual struts and poling boards, and, as the construction of the side walls proceeds, these are removed and replaced by the concrete backing at the back of the walls and struts extending from the inner sides of the wall to the central "core" between the two trenches. These last-mentioned struts are allowed to remain until the brickwork has thoroughly set; and when the covered way is completed, the central core is removed by excavation from the ends. By proceeding in this manner, the only earth &c. which has to be lifted is that which is taken out of the trenches for the side walls, and this is raised by the aid of steam cranes traversing on temporary rails laid by the side of the excavations. At the portion of the line which we are now describing, the excavations are made almost entirely through sand and gravel, (the clay being, however, reached near the foundation level,) and by carrying out the system of end excavations of the central core, the material can be readily conveyed by trollies, running on temporary rails, to points on the line where it can be screened, and that portion not required for making mortar or concrete sold at a remunerative price. If, on the other hand, the excavation was completed at once, and the part forming the core raised before the covered way was finished, great expense would be incurred on account of there being but in few cases available storage room for the excavated material, and all that portion which could not be immediately disposed of would have to be carted away.

Where the excavation has to be carried under the line of a street, a very simple way of constructing a temporary bridge is in most cases adopted, the bridge being formed for half the width of the road at one time, so as to interrupt the traffic as little as possible. Longitudinal trenches, about 2 feet 6 inches deep, are first cut in the roadway, 4 feet apart, these trenches being sufficiently long to receive timber balks which will span the intended excavation. The surface of the ground between the trenches is then lowered, and cross planking placed upon the balks, and upon this planking is laid about 1 foot of road-metalling. After the whole of the temporary bridge has been constructed in this manner, the ground is excavated beneath, and the construction of the works proceeded with, as at other parts of the line. When gas or water-pipes are met with, which will eventually be supported by the roof of the covered way, they are sustained by slinging them from balks overhead, and also by struts extending to the

ground below, these struts being replaced by longer ones as the excavation goes on. Brick sewers which cross the line of the railway are also supported in a similar manner, until removed and replaced by iron structures. Near Parliament Square Gardens, the present Victoria Street sewer thus crosses the line of the works. In this case the sewer is to be diverted, and a length of the present brick sewer replaced by a new sewer carried along the southern side of the railway, at the back of the side wall, to the low-level sewer at the Thames embankment. Another similar sewer will also be formed along the northern side of the line for some distance, so as to intercept the sewers which now extend from that side to the Victoria Street sewer, this new sewer eventually joining the existing Victoria Street sewer at the point where it leaves the northern side of the railway.

Near the end of Victoria Street, the centre line of the railway passes about 95 feet from one of the corners of Westminster Abbey, and, for a length of 300 feet near this point, a retaining wall of extra strength is being built along the southern side of the line, which here runs nearly east and west. This wall, instead of being built in bays, is 5 feet 6 inches thick throughout, and is backed with peat for a thickness of 7 feet, this thickness of peat being, however, reduced at the bottom, where the sewer already mentioned is situated, the sewer being formed for this length of 300 feet of an iron pipe 4 feet 6 inches in diameter. This system of peat backing, has been adopted at the recommendation of Mr. G. P. Bidder, acting as engineer to the Dean and Chapter of Westminster, in order to prevent any vibration being transmitted from the railway to the Abbey. We may mention here that it has been sometimes stated that the Abbey was founded on a running sand, but in the excavations which have been made for the Metropolitan District Railway only good sound gravel has been met with.

Owing to possession not yet having been obtained of the intervening property, nothing has yet been done towards the construction of the line between Parliament Square Gardens and Buckingham Row, with the exception of some slight excavations in the neighborhood of the St. James' Park station. This station will, as we have already stated, be situated close to Queen's Square Place, and it will be provided with siding accommodation. Between the St. James' Park station and Buckingham Row the line will be carried partly through girder-covered way and partly through covered way roofed with brick arches. At Buckingham Row another long length of the works in progress commences, there being first a short length of brickwork-covered way, and then about 160 yards of open cutting succeeded by works which we shall describe presently.

The difference between the construction of the brickwork-covered way and a tunnel, is chiefly that, in making the latter, the excavation is driven from the ends, whereas in constructing the brickwork-covered way the ground is opened up to the surface and then filled in again upon the top of the arches. In the case of the Metropolitan

District Railway there is no tunnel properly so called at any part. In the ordinary brickwork-covered way the arches are composed of five rings of brickwork, and have a span of 25 feet, the clear height under the crown of the arch being 15 feet 9 inches above rail-level. The curve of the crown of the arch is struck with a radius of 15 feet 9 inches, and the haunches with radii of 9 feet 6 inches, whilst the side walls have a curved batter on the face, struck with a radius of 25 feet from a centre situated 5 feet 6 inches above rail-level. The side walls are three bricks thick at the springing of the arch, and the back is carried down perpendicularly to the foundations. At intervals of 50 feet there are formed in the side walls arched recesses or manholes, 4 feet wide, 1 foot 6 inches deep in the centre, and 7 feet high, the back of each recess being formed of a horizontal arch composed of three rings of brickwork, and having a versed sine of 9 inches. The haunches of the arched covering are filled in with concrete, the upper surface being sloped off towards each side and coated with asphalte $\frac{3}{4}$-inch thick, laid on in two layers. At the back of the side walls drain-pipes are led down to near the footings, and are then carried through the walls, and, in fact, their arrangement, as well as that of the central 18-inch barrel-drain, is the same as in the case of the girder-covered way.

The side walls of the brickwork-covered way are put in in the same manner as those for the girder-covered way already described, their curved inner faces being built to properly supported wooden templates, having each course marked on them, and each furnished with a plumb-line for setting it upright. These templates extend higher than the side wall proper, and the upper part of each of them is recessed to receive lagging-boards, upon which that part of the arched covering near the springing can be built. To allow of the remainder of the arch being built, the core left between the side walls is rounded off at the top, and is spanned by centring formed of light plate-iron ribs carrying the usual lagging-boards. The ends of the ribs are supported by timbers extending from the footings of the side walls and furnished with the usual striking-wedges; and each rib is jointed at the centre, and is supported at that point by means of foot-boards and wedges resting upon the top of the central core. This plan enables the greater part of the core to be left in its place until the completion of the covering, as in the case of the girder-covered way, so that it can be removed afterwards by end excavation.

We have said that the short length of brickwork-covered way near Buckingham Row is succeeded by about 160 yards of open cutting, the railway being for this distance carried between retaining walls. The retaining walls are constructed in bays, each bay being formed of an arched panel abutting against counterforts, as in the case of the side walls of the girder-covered way. At the back of the walls the counterforts are two and a half bricks thick, whilst in front of the panels the thickness is increased to four bricks. The depth of the counterforts, measured from the face to the back, varies according to the depth of

the excavation, and the rule which has been followed is, to make the depth of the counterforts at the rail-level = $\frac{1}{3}$ the height of the retaining wall + 18 inches. The height here taken is the height above the level of the rails of that portion of the wall which is built in bays, and the top of which is generally about 18 inches below the ground-level. Above the retaining wall there is a parapet wall. The backs of the counterforts are carried up perpendicularly, and their front faces have an uniform batter of 1 in 8, so that the rule above given determines their depth from back to front at the top as well as at rail-level.

The counterforts are 11 feet apart from centre to centre, and the arched panels between them are one brick thick for a depth of 10 feet from the top of the retaining wall, and one and a half bricks thick below that depth. The versed side of the horizontally arched panels is 1 foot, and at their springing they are set back 1 foot 6 inches from the faces of the counterforts. The spaces behind the panels are filled in with lime concrete level with the backs of the counterforts, the same arrangements being made for drainage as in the case of the side walls of the girder-covered way. The distance between the faces of the counterforts of the opposite walls, at rail-level, is 25 feet, the distance between the walls at the top, of course, varying according to the depth of the excavation. The footings of the walls rest upon cement concrete carried down about 5 feet below the rail-level, as in the case of the side walls of the covered way. The parapet walls are 6 feet high above the ground-level, and are panelled, the panel being one brick, and other parts of the wall, except at the string-course and capping, one and a half bricks, thick. The retaining walls, like the side walls of the covered way, are constructed in trenches of sufficient width, the ground between these trenches being left for removal by end excavation. These retaining walls, and indeed all the details of the works, are admirably proportioned to the duty they have to perform, and by their construction very great resisting power is obtained with a comparatively small expenditure of material. The excellence of the design is also well matched by the quality of the workmanship, the whole of the brickwork which has so far been carried out in connection with the works of the Metropolitan District Railway, having been executed in a manner which reflects the greatest credit upon the contractors.

(To be continued.)

From the London Engineering, No. 46.

STEEL RAILS.

An order for twenty-two thousand tons of steel rails for the Great Indian Peninsula Railway was lately divided between the two great Sheffield houses, Messrs. John Brown & Co., limited, and Messrs.

Charles Cammell & Co., limited, and we understand that the last-named firm have orders for twenty-eight thousand tons of Bessemer rails now upon their books. Many of these orders, we are pleased to learn, are from America, for the Erie, New York Central, Pennsylvania Central, Boston and Worcester, Boston and Providence and other lines. The production of perfect steel rails is now a matter of the utmost certainty, and while very great hardness, to resist wear, is secured, the absolute strength is far beyond that of iron. At Messrs. Cammell & Co.'s, as at most steel rail mills, a "tup" of one ton is run up, by steam-power, to any height up to thirty-six feet six inches above the rail to be tested, and then tripped. The tup falls fair upon the rail, laid on three feet bearings, and it is very seldom that it is broken. It commonly bends so as to include an internal angle of about one hundred and twenty degrees. This enormous strength, where steel, in all forms, was once supposed to be peculiarly brittle, has removed the great objection to steel rails, and the fact that the American companies are ready to pay the full price shows that iron is now likely to be superseded.

The Woodhead tunnel of the Manchester, Sheffield and Lincolnshire Railway affords an interesting and instructive example of the great superiority of steel over iron rails. The tunnel, or rather, pair of tunnels, (for there are two,) are a few yards more than three miles in length, the gradient throughout being one in two hundred, and one down towards Manchester. There is a station at each end of the tunnel, and the heavy goods trains, as well as many of the passenger trains, generally stop in both directions. In getting away again, the consequent wear of the rails, just within the ends of the tunnel, is very considerable, the rails being constantly wet from the dripping of water from the roof, while they are also severely tried by the slipping of the driving-wheels of the heavy engines, the wear being aggravated by the free use of sand. Formerly not a Sunday passed without a number of rails being taken out or turned, and the life of an iron rail was but about five months on one head, and three or four on the other. Further in the tunnel, much of which is quite dry, although some portions are always showered with water from the roof, the average life of the rails was about nine months for one head and six for the other, or fifteen months in all.

Poor as the Manchester and Sheffield Company is, the directors resolved, nearly three years ago, to relay the Woodhead tunnel with steel rails throughout. The south tunnel was accordingly relaid in March and May, 1864, with seventy-five pound Bessemer rails, rolled by Messrs. Samuel Fox & Co., of Deepcar, near Sheffield; and the north tunnel was relaid at about the same time, the whole length of six miles eighty-eight yards of single line requiring about seven hundred and twenty tons of rails. The rails are of the usual double-head pattern, five inches deep, the heads about two and a half inches wide, and the stem five-eighth inch thick. They are in twenty-four foot lengths, supported upon cross-sleepers two feet nine inches apart at centres, except the sleepers which have the suspended fish-joint between them, these being two feet from centre to centre. The fish-plates and bolts are of iron. The rails are se-

cured in the intermediate chairs by compressed oak keys, in the usual manner. The ballast is mostly cinders from Messrs. Ashburys' great railway-carriage factory, at Manchester. It is of the usual thickness, and rests upon a layer of broken stone spread upon the millstone grit, which forms the bottom of the tunnel.

On Sunday last, by permission of the engineer of the line, Mr. Sacré, and in company with a gentleman well known in the profession for the interest he has taken in the introduction of steel rails, we went through the tunnel on foot, and having taken the usual precautions for the safety of the traffic, we took out rails at both the Dunford Bridge and Woodhead ends, purposely selecting the places of greatest wear. We had the original templates with us, and we took careful impressions from the ends of the rails, and measured them also, so as to obtain the exact wear. It was as nearly as possible one-eight inch off the upper table of each rail. The first rail taken up was put down at the Dunford Bridge end of the south or down tunnel March 20, 1864, and had borne twenty-four thousand and ninety-six goods, and ten thousand and forty passenger trains, as appeared from the books of Mr. Vernon, the station-master at Dunford Bridge. The goods trains were estimated at three hundred tons each, and the passenger trains at eighty to eighty-five tons, which is, we think, too low. This would give upwards of eight million tons of traffic over the pair of rails forming the line, or four million tons over the single rail taken up. The rail was in admirable condition, and was good for at least twice as much more wear upon the upper table alone, irrespective of what would be obtained from the lower table when turned over. The lower table was, however, a little indented at its bearings upon the chairs. The whole condition of the line was apparently perfect. The fish-joints were almost as close and secure as on the day they were made. It took two men, working their best, fifteen minutes to get the nuts off and the bolts out for each rail taken up. The fish-plates showed slight wear, and we really think that steel rails should have steel fish-plates, although there was little to complain of in the present instance. The line through the Woodhead tunnel is now the best portion of the Manchester, Sheffield and Lincolnshire Railway, and it is now frequently run by express trains in very little more than three minutes, or at the rate of sixty miles an hour, this speed being maintained, of course, only in the down tunnel and towards Manchester. Interesting as is this instance of the enormous superiority of steel over iron rails, it is but one of a great number which other lines now afford, and the time cannot be far distant when wrought iron rails will be almost as obsolete as the old cast iron trams of the early lines near Newcastle.

Mechanics, Physics and Chemistry.

For the Journal of the Franklin Institute.

DESULPHURIZING GOLD AND SILVER ORES.

REVIEW OF THE MOST RECENT ALTERATIONS MADE THEREIN BY DR. ADOLPHUS OTT, LATE ASSISTANT TO THE PROFESSOR OF CHEMISTRY AT THE ROYAL UNIVERSITY OF TURIN, ITALY.

Both practical miners and analysts have sufficiently proved that sulphurous gold and silver ores, when previously roasted, *i. e.*, freed of their sulphur, arsenic, antimony or other volatile substances, yield an incomparably larger amount of those precious metals than when treated directly by the amalgamation process. Whether the first of the above-named metals exists as distinct particles in its ores, though invisible to the naked eye, or whether it is combined with sulphur, generally found with it, science has not yet decided. Still, the latter is more probably the case, since two metals,* very similar to gold in their affinities, and hitherto only found in their metallic state, have recently been met in combination with sulphur.

Long before our American miners duly appreciated sulphurets and pyrites,† and attempted to extract from them the gold and silver they contained, auriferous pyrites were, according to Boussingault, worked by the inhabitants of South America, who, content with simply extracting the gold not intermingled with sulphurets, carelessly threw the tailings away in heaps. It was, however, subsequently discovered that, when thus left exposed to the influence of the atmosphere for eight or ten months, this undervalued refuse actually yielded an additional, and even an equivalent, amount of the precious metal.

Our miners, however, as soon as they were aware that their pyrites might be advantageously treated, began to experiment on various processes for desulphurizing ores. Vast sums of money were spent in procuring patents and in the erection of apparatus, which in many cases had to be transported for hundreds of miles. In the course of four years upwards of forty such patents for roasting have been granted by the

---

* Osmium and platinum.

† This is the common expression. It is derived from the Greek *πυϑιτης*, a term applied to this mineral, because, as Pliny states, "there was much fire in it," as was made apparent by friction. This term was applied also to flint and some siliceous millstones on account of their external resemblance to copper pyrites.—Dana. *Mineralogy.*

Patent Office in Washington, many of which are already in general operation. To ascertain to what extent and with what success these several schemes have been carried out, is the purpose of this article. Knowing little or nothing of many of the processes patented in this country, but found in the lists issued by the Patent Office, we are at present obliged to pass them over without further notice. As, however, this article will be continued in following numbers of this publication, we hereby invite all interested in the subject, to favor us with drawings and a full description of their several processes. We shall give them every due consideration, and doubt not that, owing to the extensive circulation of this *Journal*, every patentee of a really valuable process will thus be personally, and it may be pecuniarily, benefited.

But before entering into detail, we will briefly allude to the nature of the sulphurets in which gold and silver exist. These are mostly the following: Iron pyrites, Fe'', (with 46·6 per cent. Fe;) vitreous copper, Cu', (with 79·8 per cent. Cu;) copper pyrites, $Cu'\ Fe'''$, (34·5 per cent. Cu, and 30·6 per cent. Fe;) purple copper, $Cu'^3\ Fe'''$; Bournonit, $Cu'^3\ Se''' + 2Pe'^3\ Se'''$. They are also found in gray copper, in arsenical iron, in tennantite and in copper blende. Occasionally they have been extracted from other minerals too numerous to mention. Sulphurets containing nickel and cobalt are not unfrequently met with in Colorado; in Nevada, arsenical and antimonial ores are known to exist, whilst quite recently a very interesting mineral has been discovered in Calaveras County, Cal., namely, a tellurite of silver gold, together with antimonial nickel, native tellurium, iron pyrites, free gold and tellurite of silver. This, however, differs in many respects from the tellurite of silver gold of Transylvania, with which most miners are familiar.*

Desulphurizing has three purposes, namely: Diminution of the state of aggregation, elimination of the volatile substance and oxidation of the remaining metals; and this process has to be so conducted as to secure the greatest amount of gold and silver. As the diminution of the state of aggregation is effected by any desulphurizing pro-

---

* It is a general observation that the nearer sulphurets are found to the surface, the richer they are in sulphur; but as we penetrate into the veins below the action of atmospheric influences, we find the signs of decomposition diminished, and pyrites appear in crystals of various sizes, and the quantity of gold in the ore also increases. To the decomposition of the pyrites, is due that peculiar change in the quartz, coloring it red, making it cellular and of a spongy structure, called by miners, in many instances, "honey-combed" or "burnt," wrongly supposing its peculiar appearance to be due to ignition.

cess based upon the action of heat, we will consider the various kinds of processes.

1. In regard to the consumption of fuel.
2. In regard to the degree of oxidation obtained.
3. In regard to the loss of gold and silver thereby occasioned.

But as the consumption of fuel depends chiefly upon the construction of the furnace, as the degree of oxidation obtained (provided we can get enough heat) depends principally upon the chemically acting agencies involved, and as the loss of precious metals depends upon both, we shall, after briefly describing the respective processes merely for the better elucidation of the subject, consider them—

1. In regard to the construction of the furnace.
2. In regard to the chemically acting agencies involved in the respective process; and
3. In regard to the loss of precious metals thereby occasioned.

I. THE VARIOUS PROCESSES PATENTED IN THIS COUNTRY, CHIEFLY AS REGARDS THE CONSTRUCTION OF THEIR FURNACES.

I. *Reverberatory Furnaces.**—Most of the furnaces for roasting patented in this country are reverberatory furnaces. In these furnaces, as is well known, the fuel is not in direct contact with the ore, but acts only by its flame, being separated from it by a low wall—the *fire-bridge.* The place on which the ore is spread is called the *hearth.* It is built of fire-proof materials and is flat or hollow, and covered by a more or less elevated arch of brickwork, by which means a portion of the heat is reverberated (from *réverbérer*) or thrown back; hence the name reverberatory furnace. The draft is necessarily in proportion to the diameter and height of the chimney. It is only recently that American inventors, rejecting the usual construction, have placed a cylinder of iron, glazed inside with materials not injured by the action of the sulphur, between the flue and the fire-bridge, this cylinder, which holds the ore, being turned by machinery during the operation of roasting. We shall consider these furnaces under—*b. Reverberatory Furnaces with Revolving Cylinders.*

---

* Being the most simple, we ought first to consider those furnaces which are called "*Kilns;*" but as there has only been one proposed in this country for roasting, and as we are neither in possession of a full description nor drawing, though we have endeavored to obtain both, we must postpone our review of this kind of furnace for the next number. The patentee is Edward Kent, Esq., Melter and Refiner at the U. S. Assay Office, in New York, otherwise advantageously known by his "Gold Separator."

Various mechanical arrangements* for stirring the finely powdered ore have been introduced both in the former and in the latter kind of furnaces.

Of all the different kinds of construction, reverberatory furnaces are perhaps best adapted for roasting, because every kind of fuel can be used, the greatest effect of the fuel is obtained, the temperature can be easily regulated at will, and the whole operation supervised with the greatest facility.

a—ORDINARY FURNACES.

Rivot's Furnace is in operation in California. It is said that rock, paying $10 in silver per ton, could be worked to advantage in Europe, by subjecting it to Rivot's process. The furnace is so constructed that the flame cannot touch the ore in its passage from the fire-bridge to the flues, having a high fire-bridge, arch and flues, the arch being about thirty inches above the hearth, which is thirteen feet in size.

Hence it follows that there must be a great loss of heat by adopting this furnace.

The flame is also prevented from touching the ore by the introduction of steam of about fourteen pounds pressure per square inch, near the fire-bridge and through pipes, passing through the arch. Great importance is attached, and much credit taken, for the peculiar mode of introducing the steam into the furnace, it being said to form a protection against the access of air to the ore, Mr. Rivot considering it necessary that the air be *completely excluded* from the ore, in order to avoid the formation of sulphates, which are said to be injurious to the process of amalgamation.

With this we agree; but as concerns the plan adopted, if it is a really practical way to avoid the formation of sulphates, or rather, an impractical and costly one, we shall investigate under the appropriate heading. We only regret that Mr. Rivot has not furnished us with some details relative to his mode of creating combustion without any air entering into the furnace. If such a result can really be accomplished, it would be of no little importance to industry; but as Mr. Rivot merely gives us a rough statement, without describing any arrange-

---

* Mechanical arrangements for stirring the ore in ordinary reverberatory furnaces have long been in use in England. They are, however, now, for the most part, superseded by the American ones. We find such a one already described in the *Berg-und-Hüttenmännischen Zeitung*, 1852, page 265, and in C. F. Plattner's *Vorlesungen über allg. Hüttenkunde I.*, page 201.

ment, and as we know that, by the best improvements made in this line, the fire-gases which pass through the chimney always contain at least 10 per cent. of free oxygen, we have reason to doubt that Mr. Rivot fulfills what he assumes.

Corbett's Furnace, being twelve feet long by eight feet wide, is said to receive a charge of four tons of ore. In the construction of this furnace the arch is formed by a boiler, which is intended to supply the steam necessary for the propulsion of the machinery in crushing and amalgamating. Through the centre of the furnace extends longitudinally a hollow shaft, provided with arms, holding peculiarly shaped shovels, which also are hollow and kept constantly filled with water. They are intended by their oscillation to keep the ore in motion, while their spiral shape gives it a longitudinal direction.

It is said that the roasting of four tons of ore would be effected in five to six hours, and that twelve tons would be desulphurized in twenty-four hours. For roasting twelve tons three cords of wood are deemed necessary, and the total cost of roasting this quantity is said to amount to $42, while it is said it could not be done for less than $128 by the ordinary system.

In regard to this furnace, we find but little originality, except in the arrangement with the boiler forming the arch, but as its lower surface has to be lined with a fire-proof material, to protect it from the sulphurous vapors continuously generated, there can be but little heat saved. The mechanical arrangement for keeping the ore in motion is good, and there may be something new and peculiar in the form of the shovels. As the patentee claims that, by his process, compared with an ordinary furnace, two-thirds of the cost of roasting are saved, we would like to know what furnace he means, there being so many in use. Again, we cannot see why the oscillating shovels have to be constantly kept filled with water.

(To be continued.)

JOURNAL BEARINGS.

By Coleman Sellers.

At the stated meeting of the Franklin Institute, held October 19th, 1866, Mr. Nystrom made some interesting remarks on the use of a compound of cast iron and steel, for journal-boxes and the like. He

also gave a tabular statement of the properties of cast iron and steel, as compared with brass, which showed conclusively in favor of the former. At the conclusion of his remarks, I am made by the reporter to say: "Cast iron bearings work very well, and perhaps better than brass." As these words do not fully express what I said, and the subject is an interesting one, I propose to treat it more at large in these pages. In the infancy of the mechanic arts, wooden shafts or journals revolved in wooden boxes; wagon wheels, with hubs of hard wood, ran on wooden axle-trees. Then, cast iron boxes were driven into the wooden hubs, one at each end of the hub, and the wooden axle was plated, top and bottom, with wrought iron. But now, the model trotting wagon, which must run with the least possible friction, has a cast iron box the whole length of the hub, neatly fitted to a case-hardened wrought iron axle. Thus, in the history of the wagon, we see some little of the progress in perfection of journals.

Wood, stone, brass, cast iron, steel and various soft alloys, under the general name of Babbet metal, have been, and are still, used as journal bearings. Oliver Evans, in his *Millwright's Guide*, published in 1795, tells how to proportion the cast iron gudgeons (as the journals are called) of water-wheels, and describes the stone bearings in which they are to revolve, enlarging on the necessity of surface to resist the pressure of the weight of the wheel, and of the proper methods of conducting off the heat generated by the friction. The modern engineer is called upon to apply his knowledge of the nature of various materials for journal bearings, adopting such as each case may require.

Holding that the perfection of mechanism calls for a hardened cast steel journal, ground true, and polished—running in a hardened cast steel bearing, accurately fitted to the bearing, with the pressure equally distributed over the whole surface, so arranged as to admit of thorough lubrication. In general terms, the harder the surfaces of both journal and bearing, the better do they work. But as the cost is an essential consideration, other and cheaper methods have to be resorted to in practice. In the rolling machinery for iron, the massive rolls have their journals, or necks, as they are called, supported in hard brass boxes, the pressure being very great, from the enormous strain to which they are subjected in the process of rolling bars or sheets of iron and steel. These brass bearings rapidly wear out, and require to be renewed. To save the bearings, many compounds of copper, tin, antimony &c. have been tried, such compounds melting at a low temperature, and capable of being cast into cast iron cases,

to hold them in shape—presenting as the wearing surface to the journal a softer material than the brass. Such bearings do last longer than brass, and cost much less; but practice shows that the wear takes place in the journal of the roll, and not in the bearing, and thus the more expensive part of the machinery suffers. The reason of this is, the soft metal holds the hard particles of the dust and grit from the cinder &c. to which the journals are always exposed, each little particle becoming a cutting point to gradually wear down the hard metal of the journal; thus imitating the very means which a skillful workman would resort to, did he desire to grind down a similar mass of cast iron. The grinding clamps used by machinists to grind to size, cylindrical bars of hard metal, are usually made of cast iron, lined with soft metal—lead, for instance—and the emory used in grinding is held by the soft metal, which wears away very slowly in the process, while the cylinder of hard metal revolving in the clamps is quite rapidly reduced, just as the journal of the roll is worn down by the grit held by a soft metal bearing. Now, although these soft metal bearings do not answer for such purposes as the one just described, yet it does not follow that they are always to be avoided. There are cases in which they recommend themselves by their facility of construction and cheapness, and when they are protected from dust and grit they do not injure the journal.

The surface of journals and their bearings should always be proportioned to the work they have to perform, *i.e.*, to the pressure to which they may be subjected. A hardened steel journal in a hardened steel bearing, will work under a given pressure with less surface than would be required for a soft iron journal in a cast iron bearing. But when it is possible to obtain sufficient surface, the cast iron bearing, from its cheapness, ease of construction, hardness and that property which it possesses of rapidly giving off the heat from friction, recommends itself as best suited for the majority of cases.. To use cast iron successfully as a bearing, it should not be subjected to more pressure than about one hundred pounds to the square inch of surface exposed to the pressure, and the pressure should be uniform over the whole surface. All first-class machinists' tools—as, for instance, planing machines for metals—abound in examples of cast iron bearings, and in very many cases the bearings are made without any means of compensating for wear; that is, they consist of cylindrical holes in the solid metal, in which the journals fit accurately. And instances abound in which journals and bearings so made, have shown no appreciable

wear after years of hard work. In the construction of machines with rigid frames of metal, the journal bearings are mostly cast as part of the frame, bored in line with one another, and are what are called rigid bearings. When, however, the metal bearings are attached to wooden frames, as in the case of line shafting for conveying motion from the steam-engine to the various machines in a factory, the bearings should be so made that they can accommodate themselves to the varying positions of the shafting, and insure an equality of pressure over their surface. Bearings of this character, of cast iron, are now in almost universal use for shafting purposes, under the general name of swivel or ball and socket hangers. As the consideration of the proper proportion of the wearing surfaces to the work, in the use of these swivel hangers, may be interesting to some of the readers of this *Journal*, I shall reserve it for a separate article in the next number.

From the London Civ. Eng. and Architects' Journal, October, 1866.

ON TREATMENT OF MELTED CAST IRON AND ITS CONVERSION INTO IRON AND STEEL BY THE PNEUMATIC PROCESS.*

By Mr. Robert Mushet.

In the year 1815, my father, Mr. David Mushet, took out a patent for the manufacture of refined iron direct from the blast-furnace.

For this purpose he erected a small blast-furnace, 30 feet high, blown by means of three tuyeres, with a pressure of blast of about three pounds and a half per square inch. These tuyeres were arranged so as to dip down upon the surface of the melted iron in the hearth of the furnace, and when the hearth was full, or nearly full, the tuyeres were partially below the surface level of the melted iron. There was no difficulty experienced in keeping the melted iron in a liquid state in the middle of the hearth, but round the sides the refined iron chilled, and formed what is technically termed "scull," and this rendered it very difficult, and sometimes impossible, to tap the furnace and run off the portion of the metal which retained its fluidity. When the tapping took place, the metal flowed from the furnace intensely heated, and throwing off the most brilliant scintillations. The temperature of the metal, like that of ordinary refined metal, was far higher than that of pig iron produced under the regular working of a blast-furnace. The pigs of metal obtained were perfectly solid, showing, when broken, a dense white steely grain. They were so strong as to bend before they broke, and occasionally they could not be broken at all, though struck by the heaviest

---

* Read before the British Association, Nottingham, 1866.

sledges wielded by the most powerful men; the metal was, in fact, crude cast steel, and could be chipped with a cold chisel, and, when annealed, was susceptible of being forged at a low heat to some extent. The defect in this process was that, as in the refinery, the waste of metal was excessive, owing to the surface action of the blast upon the melted iron for a prolonged period. The difficulty of keeping the hearth open, and of tapping, arose merely from the small size of the furnace and hearth, and the weakness of the blast. The iron was, however, decarbonized, so as to be in the condition of crude cast steel, too highly oxygenated, however, to be forged into bars of commercial value.

The experiment I have described was, I believe, the first practical step taken in the development of the pneumatic process, though it was certainly not undertaken with any idea of producing either malleable iron or steel by that process, but simply a highly decarbonized refined metal. About the year 1850, I made experiments with some very highly-blown refined iron from the Parkend Ironworks, in the Forest of Dean, and found that, when alloyed with manganese, this refined metal could be forged into sound bars of very hard steel, too hard, indeed, for any practical purpose, but, nevertheless, solid, and free from seams or flaws, indicating that if the iron could be sufficiently decarbonized whilst in the melted state, steel of marketable quality might be obtained by simply adding some metallic manganese to the decarbonized metal.

In the autumn of 1856, Mr. Henry Bessemer read a paper at the meeting of the British Association in Cheltenham, which, whilst it filled the scientific as well as the practical world with astonishment, did not in the least surprise me, except in the one circumstance of its being possible to maintain a tuyere beneath a heavy column of melted cast iron. That, indeed, appeared to me most surprising, as I was well aware of the highly destructive action of the iron slag which is generated by the action of atmospheric air upon melted cast iron. However, what I considered impossible had actually been accomplished by Mr. Bessemer, and the first great advance towards rendering steel as cheap as iron had been inaugurated by that gentleman.

Mr. Bessemer's process consisted in forcing air through melted cast iron by means of tuyeres situated beneath the surface of the melted iron. When melted cast iron is subjected to this process, the silicon contained in the iron is first combined with the oxygen of the blast, and thrown to the surface as a light, frothy, gray slag. Next, the carbon of the melted iron enters into combustion, and, lastly, the iron itself is attacked and consumed with the development of an intense temperature, sufficient to keep the iron, though freed from carbon, in a perfectly liquid state.

When the silicon and the carbon have been nearly or wholly eliminated from the cast iron operated upon, the product obtained is either crude cast steel or iron, according to the degree of decarbonization arrived at. Ingots cast from this metal are more or less unsound, and, when forged, they frequently crack or break off, owing to their red-shortness, and are wholly unfit for the requirements of commerce. More-

over, whenever the melted cast iron operated upon contains sulphur and phosphorus to any notable extent, the decarbonized iron is found to be so crude and brittle that it cannot be forged at all, and is, in fact, less valuable than the pig iron it has been made from. Hence, only the purest coke pig irons of Great Britain are at present suited for Mr. Bessemer's process, and these are comprised in the hematite pig irons, the Forest of Dean pig irons, the Weardale spathose irons, and the Blanavon and Pontypool Welsh brands; these latter two being, however, far inferior to the other brands for the pneumatic process.

Mr. Bessemer naturally inferred that he should be able to produce both cast steel and iron by his process alone, and it by no means detracts from his merits that he happened to overlook the fact that iron exposed in the melted state to the action of oxygen becomes as it were debased. Some persons term it "burnt iron," but I call it "oxygenated iron;" and oxygenated iron can never of itself constitute a commercially valuable article. This oxygenation can be prevented when a metal is present whose affinity for oxygen is greater than the affinity of iron for oxygen, and it can be remedied when such a metal is subsequently added to the oxygenated iron. When Mr. Bessemer read his paper, I foresaw all the difficulties he would have to encounter from oxygenation of his iron, and I knew that the remedy was simple and attainable, provided a suitable metal could be found at such a cost and in such quantities as would render its use practicable on the large scale. Out of several metals possessed of the required properties, I selected the metal manganese as found abundantly in the spiegeleisen or spathose pig iron of Rhenish Prussia, and combined therein with carbon and iron, the iron forming a convenient vehicle by means of which I could introduce the metallic manganese into melted decarbonized iron treated by Mr. Bessemer's process. My first experiment was with some Bessemer metal prepared at the Victoria Ironworks from hematite pig iron. The experiment was made in small crucibles containing only a few ounces, the Bessemer metal being melted in one crucible, and the spiegeleisen in another; the melted contents of the crucibles were then mixed, and a small ingot cast. This ingot was forged into a bar of excellent cast steel, which was doubled, welded and made into a chisel, and was found for all practical purposes to be cast steel of fair average quality.

I then extended the scale of my experiments, and operated with steel melting pots, containing from 40 lbs. to 50 lbs. of Bessemer metal each, and melting the spiegeleisen in smaller crucibles. The most complete success resulted from these experiments, and Mr. S. H. Blackwell having subsequently supplied me with a small blowing engine, capable of maintaining a blast of 10 lbs. pressure per square inch, I operated upon quantities of melted cast iron of from 500 lbs. to 800 lbs., and with similar success, the Bessemer metal being wholly freed from unsoundness, redshortness, and other defects which had precluded its being forged or rolled into a marketable product. The British pig irons that I found best suited for the joint processes of Mr. Bessemer and myself were the Lancashire and Cumberland hematite iron, the Weardale spathose iron

and the Forest of Dean pig iron. Of foreign brands, the Indian charcoal pig, and some manganese pig iron from Sweden, gave the best results, though not so satisfactory as those obtained when hematite coke pig irons were employed. I had, meanwhile, secured my invention by letters patent, dated September 22d, 1856. This patent lapsed in 1859, through non-payment of the stamp-duty of £50, owing to some unaccountable oversight of the trustees to whom I had been advised to entrust my patent rights. My invention thus became public property, and I was deprived by this accident of all remuneration for an invention which every person, practically acquainted with the manufacture of Bessemer metal, will admit to be of immense value.

I speak, no doubt, as an interested party, and my opinion is, therefore, open to criticism; but I venture to submit that an invention such as that described in my last patent, places all who have been benefited by its use under a moral obligation to recognize my claims to remuneration; for although by the accident of the non-payment of the stamp-duty my invention became public property, I still think that the accident ought not to debar me from the reward that I am morally entitled to, and could have commanded to so large an extent, but for the oversight of those on whom I relied.

Much remains to be done to extend the use of the pneumatic or Bessemer process to the ordinary brands of pig iron at present considered to be unfit for this purpose. I am, I believe, in possession of the requisite knowledge to accomplish all this, and I am only awaiting the opportunity to do so, whenever the Titanic Company, with whom I am associated, shall consider that the proper time has arrived for them to erect a suitable Bessemer apparatus at their works.

The means are, I believe, as simple and efficacious as is the addition of spiegeleisen, now invariably employed by all Mr. Bessemer's licenses in England, and the resulting advantages will be proportionally great.

In Sweden, the Bessemer process has been carried out by operating upon certain brands of Swedish pig iron containing a considerable alloy of metallic manganese; the result is, that with the subsequent addition of a little of the same manganesic pig iron in lieu of spiegeleisen, a workable steel is produced of moderate quality, but too seamy and unsound to be of much value for tools, and not nearly so tough and strong as the Bessemer steel made in this country from our own coke pig irons, and it can never enter into competition with our English Bessemer steel. In treating melted cast iron by the pneumatic or Bessemer process, the simplest plan is to deprive the iron of the whole of its silicon and carbon. In this case, the addition of a given weight of spiegeleisen, or of any similar metallic compound of iron and manganese containing carbon to a given weight of decarbonized cast iron, will ensure results of tolerable uniformity as to the hardness or temper of the steel produced. The effect of adding spiegeleisen to Bessemer metal is as follows:

The metallic manganese, by its superior affinity for oxygen, de-oxygenates the decarbonized metal, and renders it sound and free from red-shortness.

The carbon of the spiegeleisen steelifies the mixture, and improves it when stiff or hard metal is required.

The iron of the spiegeleisen adds to the weight of the charge, and may, therefore, be considered as a gain to nearly the amount of its weight.

The silicon which is found in spiegeleisen has the effect of reducing the boiling or agitation of the pneumatized metal when poured into moulds, and is therefore beneficial, and it is not present to any injurious extent in spiegeleisen.

The hardness or temper of the Bessemer steel may be increased at pleasure by increasing the dose of spiegeleisen.

When spiegeleisen is added to Bessemer metal containing sulphur, and the pneumatic blast is turned on so as to eliminate the carbon and manganese of the spiegeleisen, a portion of the sulphur of the pneumatized iron is carried off by the manganese, and thus, by repeated additions of spiegeleisen and subsequent eliminations of its manganese, pneumatized cast iron may be wholly desulphurized.

In a similar manner, Bessemer metal containing phosphorus may be dephosphorized by employing titanic pig iron in repeated doses to eliminate the phosphorus, and when both sulphur and phosphorus are present, both may be eliminated by repeated additions of spiegeleisen and titanic pig iron, the pneumatic blast being turned on after each such addition made to the pneumatized cast iron.

The pneumatic process of Mr. Bessemer, in conjunction with my spiegeleisen process, is producing a revolution in the engineering world, and in all the departments of art dependent upon engineering, to an extent almost incredible, and the magnitude of its ultimate effects it is impossible fully to foresee. Mr. Bessemer's name will be remembered in connection with this, the greatest metallurgical invention the world has ever seen; and I venture to hope that I may not be wholly forgotten as having supplied the link which was wanting to render Mr. Bessemer's process what it now is. As I have had much experience in matters relating to the steel manufacture, it was not surprising that I should at once have been able to devise the remedy for the one solitary defect which marred the success of the pneumatic process at its outset.

Translated for the Franklin Institute Journal from the Comptes Rendus, Vol. LXIII., page 771.

A NEW FORM OF THE HOLTZ MACHINE.

Memoir by M. Bertsch.

Notwithstanding the theory that its author gives of the Holtz machine, it appears to me a complicated solution of the problem I propose to solve. I have nevertheless tried, in the construction of this new apparatus, to banish all doubt about the action of its parts, so that one cannot mistake the origin of its effects. Also, though

analogous in form, it is easily seen that this generator is very different from that of which I have previously spoken, (*i.e.*, the Holtz machine.)

It is not composed of two disks of isolating substance, but of one alone, so that we need not consider the action of a layer of interposed air in the production of the phenomena. The disk, formed of a thin sheet of isolating material, is mounted on a shaft of the same substance, and can, by means of a handle or treadle, be rotated with the rapidity of ten or fifteen turns a second.

Two collectors with metallic points, but not connected, are placed perpendicularly to the plane of the disk, and at the opposite extremities of its diameter, and serve as the origin of the manifestation or display of the double current which is created. Each of these collectors is furnished with a movable arm, which serves as an electrode, each ending with a ball, and they separate from each other at right angles, or approach until they meet. A conductor with a large surface is connected with one of these poles to increase the tension.

Behind the plate, and parallel to it, can be placed, if desired, one or more sectors or thin plates of isolating material, not in contact with the last, but at a little distance from it. These movable sectors can act either alone, or superposed one on another. These sectors are of about sixty degrees each, and of a triangular form. They serve as inductors.

To start the machine it is sufficient to rub one of the sectors lightly with the hand, which electrifies its surface, and to place it in the position indicated. The wheel being put in motion, a series of sparks spring without intermission between the two electrodes. Whether the motion of the wheel is interrupted or no, the apparatus remains charged, as does the ordinary electrophorus. In a dry atmosphere, the flow of electricity will last for several hours without any sensible diminution; this seems to prove theoretically that it would continue indefinitely if the air was isolated in an absolute manner.

If behind the first we add a second sector, equally electrified by friction, the quantity of electricity is doubled, without, however, augmenting the tenison, because the surface of the conductor remains the same. A third and fourth sector superposed on the first, are so many new inductors, and augment the quantity, which is only limited by the distance of the electrified surfaces, the diameter, the rapidity of the wheel and the promptness with which it regains equilibrium by the electrodes.

With a disk of fifty centimeters (twenty inches) of hardened rubber,

and movement of ten turns a second and two sectors, you can obtain, almost without interruption, sparks of from ten to fifteen centimeters (four to six inches) having sufficient tension to pierce a piece of glass of one centimeter (?) thickness, and can illuminate continuously a tube of more than one metre (three feet three inches) filled with rarified gas, and set fire to combustible material at a short distance.

This plate can charge in thirty or forty seconds a battery of two metres (twenty-one and a half square feet) of interior surface, which will volatilize a sheet of gold leaf, and burn one metre of iron wire employed in the lightning arrester of telegraphs.

Finally, by the simplicity of its construction, this apparatus seems to realize practically the idea of a continuous electrophorus, and of a convenient and permanent source of electricity. By the effects, relatively of importance, which it gives, and the yet doubtful questions, on the induction of statical electricity, which it helps to solve, it seems to me of interest.

THE LAST SCIENTIFIC TOY.

We have just received from Wilson & Hood, No. 626 Arch Street, the last photographic novelty, in the shape of some cigar-holders made of paper and quill, each showing a blank medallion, on which, however, a photograph is developed in a few moments when the holder is used for its intended purpose. It appears from experiment that the ammonia of the smoke is the developing agent, but the exact nature of the action as yet defies the sagacity of the most learned in photographic affairs. These articles are sold for a trifle, and form a good addition to our already long list of scientific toys.

From the London Engineering, No. 46.

FILTERING WATER.

The success with which animal charcoal has been employed for filtering the East London Company's water, as supplied to the seven hundred occupants of Miss Burdett Coutt's model lodging-houses in Columbia Square, has been remarkable. Dr. Frankland has found (and we drew attention to the fact in *Engineering* of the 26th ult., page 325,) that the solid impurities were reduced from 30·2 grains per gallon to

21·76 grains, the organic matter from 1·25 grains to 0·28 grain, and the hardness (*i. e.*, the number of grains of bicarbonate of lime or its equivalent in one hundred thousand parts) from 20·2 to 7·1.

One of the most energetic purifiers of water by filtration is Mr. Thomas Spencer's artificially prepared magnetic oxide of iron. Filter-beds, in which layers of this material are overlain by sand, are now in use at Wakefield, Southport and Wisbeach. In the case of Wakefield, supplied from the Calder, the water as it is taken from the river is very impure. Mr. Filliter, the engineer to the Wakefield water-works, as he is also to those of the Corporation of Leeds, has two filter-beds of five hundred square yards each, at Wakefield, having each a layer of nine inches of Mr. Spencer's oxide overlaid with sand. Two more beds, of six hundred square yards each, are to have a layer of oxide of the same thickness, and thus nearly half an acre of filtering oxide will soon be in use in Wakefield alone. The effect upon the water is magical. It is not only cleared in appearance, but its organic impurities are nearly all removed. At Southport the water contained carburet* of iron, which turned the tea made with it to the blackest of ink. This has been also removed by the oxide of iron.

In preparing his oxide, Mr. Spencer calcines red hematite ore along with hard-wood sawdust for five or six hours in a close retort. This is all that is required to convert the ore into a black granular mass, which is strongly magnetic. Delivered at the works where it is employed, the cost is about £4 per ton.

From the London Chemical News, No. 351.

ON THE ABSORPTION AND DIALYTIC SEPARATION OF GASES BY COLLOID SEPTA.

By Thomas Graham, F.R.S.

It appears that a thin film of caoutchouc, such as is furnished by varnished silk or the transparent little balloons of india rubber, has no porosity, and is really impervious to air as gas. But the same film is capable of liquefying the individual gases of which air is composed, while oxygen and nitrogen in the liquid form are capable of penetrating the substance of the membrane, (as ether or naptha does,) and may again evaporate into a vacuum and appear as gases. This penetrating power of air becomes more interesting from the fact that the gases are unequally absorbed and condensed by rubber, oxygen $2\frac{1}{2}$ times more abundantly than nitrogen, and that they penetrate the rubber in the same proportion. Hence the rubber film may be used as a dialytic sieve for atmospheric air, and allows very constantly 41·6 per cent. of oxygen to pass through, instead of the 21 per cent. usually present in air.

---

* The writer no doubt means Carbonate.—Ed., H. M.

The septum keeps back, in fact, one-half of the nitrogen, and allows the other half to pass through with all the oxygen. This dialysed air rekindles wood burning without flame, and is, in fact, exactly intermediate between air and pure oxygen gas in relation to combustion.

One side of the rubber film must be freely exposed to the atmosphere, and the other side be under the influence of a vacuum at the same time. The vacuum may be established within a bag of varnished silk or in a little balloon, the sides being prevented from collapsing by interposing a thickness of felted carpeting between the sides of the varnished cloth, and by filling the balloon with sifted sawdust. For commanding a vacuum in such experiments, the air-exhauster of Dr. Herman Sprengel* is admirably adapted. It possesses the advantage that the gas drawn from the vacuum can also be delivered by the instrument into a gas-receiver placed over water or mercury. The "fall tube" has merely to be bent at the lower end.

The surprising penetration of platinum and iron tubes by hydrogen gas, discovered by MM. H. Sainte-Claire Deville and Troost, appears to be connected with a power resident in the same and certain other metals to liquefy and absorb hydrogen, possibly in its character as a metallic vapor. Platinum in the form of wire or plate at a low red heat may take up and hold 3·8 volumes of hydrogen, measured cold; but it is by palladium that the property in question appears to be possessed in the highest degree. Palladium foil from the hammered metal, condensed so much as 643 times its volume of hydrogen, at a temperature under 100° C. The same metal had not the slightest absorbent power for either oxygen or nitrogen. The capacity of fused palladium (as also fused platinum) is considerably reduced; but foil of fused palladium, for which I am indebted to Mr. G. Matthey, still absorbed 68 volumes of gas. A certain degree of porosity may be admitted to exist in these metals, and to the greatest extent in their hammered condition. It is believed that such metallic pores, and indeed all fine pores, are more accessible to liquids than to gases, and in particular to liquid hydrogen. Hence a peculiar dialytic action may reside in certain metallic septa, like a plate of platinum, enabling them to separate hydrogen from other gases.

In the form of sponge, platinum absorbed 1·48 times its volume of hydrogen, and palladium 90 volumes. The former of these metals, in the peculiar condition of platinum black, is already known to take up several hundred volumes of the same gas. The assumed liquefaction of hydrogen in such circumstances appears to be the primary condition of its oxidation at a low temperature. A repellent property possessed by gaseous molecules appears to resist chemical combination as well as to establish a limit to their power to enter the minuter pores of solid bodies.

Carbonic oxide is taken up more largely than hydrogen by soft iron. Such an occlusion of carbonic oxide by iron at a low red heat appears

* Chemical Society's *Journal*, ser. 2, vol. iii., p. 9, (1865.)

to be the first and necessary step in the process of acieration. The gas appears to abandon half its carbon to the iron, when the temperature is afterwards raised to a considerably higher degree.

Silver has a similar relation to oxygen, of which metal the sponge, fritted but not fused, was found to hold in one case so much as 7·49 volumes of oxygen. A plate of wire of the fused metal retains the same property, but much reduced in intensity, as with plates of fused platinum and palladium in their relation to hydrogen.—*Proceedings of the Royal Society.*

From the London Engineering, No. 41.

DISTILLING SEA-WATER.

In the northern part of Chile, near the coast, rain seldom or never falls, and fresh water, in large quantities, is nowhere obtainable. On the opening of the Copiapo Railway, from the port of Caldera inland, it became necessary to distill sea-water for the supply of the locomotives, and the quantity distilled at length became as much as 15,000 gallons daily. As coal on the coast costs from 12 dollars to 15 dollars per ton, the process of distillation was in any case an expensive one; but the mode of distillation was such, that as much as 40 lbs. of sea-water were, we are informed, sometimes evaporated per pound of coal, so that the cost was not as great as would at first sight appear. This rate of evaporation would, of course, be impossible, except with special evaporating apparatus, the action of which may be easily understood. The engineer to the line, Mr. W. W. Evans, ordered from Mr. A. M. Perkins, of London, five steam boilers, four of which contained each a large number of condensing tubes, instead of the usual furnace and fire tubes. Indeed, these four boilers were true surface condensers, although the steam was condensed in them into hot water of considerable temperature and under considerable pressure. The boilers were all thickly clothed with felt and ashes to prevent radiation, and were filled to the usual water level with sea-water. A fire was maintained in the furnace of the first boiler of the series, and the water in it was thus evaporated under a pressure of perhaps 100 lbs., and at the usual rate of 8 or 9 lbs. per pound of coal. The steam was led into the tubes of the next boiler, where it imparted its own heat to the sea-water surrounding the tubes, and thus raised steam, which was maintained at a somewhat lower pressure than that in the first boiler. Thus, suppose the steam in the first boiler to be at 100 lbs. pressure, and to have a temperature, as it rose from the brine, of 345°, (being a little higher than the temperature of steam rising from fresh water under the same pressure,) and suppose the steam in the second boiler to stand at 65 lbs. and at 315°. Here is a difference of temperature of 30°, sufficient for condensation, and thus all the steam from the first boiler would be condensed into water of 345°, or a little less. In condensing it would give off rather more than

875° of latent heat to the water in the second boiler, so that each pound of steam condensed would generate, from feed-water at 70°, about $\frac{3}{4}$ lb. of additional steam of 65 lbs. pressure. The third boiler might be worked at 35 lbs. and at 280°, the fourth at 14 lbs. and at 250°, and the fifth at atmospheric pressure and 220°, (according to the saltness of the water, fresh water boiling at 212°.) In this way there would be a difference of 30° or more between each successive pair of boilers, a difference sufficient to insure condensation as the steam raised in one was let into the tubes of the boiler worked at the next lower pressure. As lower and lower temperatures were met in the series of boilers, each pound of steam used for heating would successively give off a higher proportionate quantity of steam in the boiler next below it. Thus, if one pound of steam in the fired boiler would generate three-fourths of a pound of steam in the boiler worked at the next lower pressure, the steam from the latter would generate, not three-fourths as much as the fired boiler, but rather more than three-fourths its own weight in the third boiler in the series. This is supposing the water to be fed to the boiler in each case at a moderately low temperature, say 60°, and supposing the condensed steam to be taken off at the temperature of condensation, say 220 to 345°, in the different boilers. If, however, the high temperature of the condensed steam were utilized in heating the feed-water, a higher proportion of the heat of each pound of steam would be extracted from it.

Mr. Evans has informed us that as much as 40 lbs. of water were evaporated per pound of coal, in the case of the range of boilers at Caldera; but we believe no definite report has ever been made upon their performance. We do not even know the exact pressures at which they were worked, and we have taken the pressures already mentioned only for illustration. Supposing a difference of temperature of 10° or 15° to be sufficient for the active condensation of steam, then a lower range of pressures would not only suffice, but would give better results than we have roughly estimated, results which show about 25 lbs. to 30 lbs. of water evaporated per pound of coal, without reckoning the considerable loss by blowing off to prevent salting.

From the London Journal of the Society of Arts, No. 689.

(Continued from Vol. LII., page 387.)

CANTOR LECTURES—SUBMARINE TELEGRAPHY.

By Fleeming Jenkin, Esq., C.E., F.R.S.

5. *Proposed Improvements.*—Reels have been proposed in ships as a substitute for the coils in tanks. Their great mass in motion would be difficult to control. Mr. Siemens actually tried, with some success,

a reel for a light cable, and drove it with an engine; he abandoned the plan for the old system. The defects which the reel is supposed to remedy do not exist. Captain Selwyn has proposed to use a reel floating in the sea, ingeniously retarded by paddles, which would prevent too much slack from being laid. It hardly becomes a landsman to tell a sailor that such a reel would be unmanageable; but the difficulties of coiling in water, of launching the reel if coiled on land, of protecting the surface of the cable against collisions, of testing the cable, of remedying any deefct, should any arise, and even of preventing one coil from cutting into those immediately below it, seem unavoidable, and the defects the invention is supposed to remedy are imaginary. Buoys have been proposed to relieve the cable from part of its weight; any hollow buoys would be crushed very shortly after leaving the surface. Mere wooden floats would do little, and be difficult of attachment. This invention also labors under the disadvantage of being unnecessary, since cables can be paid out with twelve hundred weight strain or less, which will bear one hundred and fifty hundred weight. Vanes on a cable, opposing its slipping backwards, would be correct in principle, although probably quite impracticable; the result aimed at is obtained by increasing and roughing the surface of the cable. Most engineers who have had practical experience deprecate any attempt to catch the cable by nippers after it has left the ship. The danger of fouling is more considerable than the extra chance of safety given by the nipper. Lastly, many proposals have been made for some kind of elastic arrangement, to compensate for the change of strain caused by the rise and fall of the ship. When cables are paid out so nearly horizontally as is now the case, these arrangements, even if practicable, are not required, the alteration of the strain, caused by the motion of the ship, is quite inconsiderable, and there is great difficulty in devising any elastic arrangement which by the inertia or momentum of its parts would not aggravate the evil, such as it is. Unless when going very slow, in very bad weather, the best conceivable elastic arrangement would be useless, if not injurious.

6. *Repairs in shallow water.*—So long as the outer wires of a cable remain sound, repairs in shallow water are always easily effected. The cable is caught by a grapnel, lifted to the surface, cut, tested, and if the fault be near at hand, one end of the cable is buoyed, the other end passed round a drum driven by a steam-engine, which gradually hauls in the cable till the fault is found, when it is repaired, the cable again paid out, and spliced at the part buoyed. Bad weather and a rocky bottom are the chief difficulties to be contended with. Sometimes the cable is not cut or hauled on board, but simply underrun, passing over a grapnel or sheave hung outside the bows of the ship; as the ship moves forward the cable rises in front and is again lowered behind the ship. There are many points of practical interest connected with repairs in shallow water, and the lecturer refers those who require further details to Mr. F. C. Webb's paper in the *Transactions of the Institution of Civil Engineers*, 1857-58. If the bottom be good, *i.e.*, sandy or muddy, cables can always be recovered within one hundred fathoms, and they are frequently hauled up in much greater depths.

7. *Repairs in deep Seas.*—The only method hitherto practised with success has been to commence in shallow water and gradually haul the cable on board, as described above. By carefully keeping the cable hanging vertically from the bows the strain on it will not greatly exceed in calm weather the weight of the cable hanging plumb from the ship. Cables have been recovered in this way out of depths of one thousand and one thousand five hundred fathoms at the rate of about a mile per hour. Messrs Newall were very successful in the Mediterranean in recovering many cables by this plan, and the lecturer has seen a cable hang for three days at the bows of a ship where the depth was eight hundred fathoms, while the ship pitched violently owing to bad weather; the cable did not break, and was relaid with success. Even in this case the rise and fall of the ship did not injure the cable, but the change in the strain on the cable was great, and any good elastic compensation would have been useful; the cable itself, yielding say one-quarter per cent. in a mile, gives a certain elasticity. Although this method of recovering deep sea cables is not hopeless, the risks are great; bad weather or a weak point in the cable entail almost certain failure. A good nipper to catch the cable, should it break in board, as it frequently does, might be of material service. Few persons will be sanguine enough to expect that a cable could be steadily picked up for one thousand consecutive hours, or say forty days, with about half its theoretical breaking strain necessarily always upon it. We should, therefore, be grateful to the engineers in charge of the late Atlantic expedition for showing us that even in two thousand fathoms of water the attempt to hook a cable with a grapnel is far from hopeless. The chance of success by this method will now be examined. If a cable were laid absolutely taut along the bottom of the sea, when hooked by the grapnel it would rise a little way in virtue of its elasticity; if it stretched one per cent., by the time ten miles of it were off the ground the apex would be half a mile from the ground, a result few are prepared to expect; but the strain on the cable where caught would be very great, equal to the weight of about twenty-four miles of the cable, though the weight on the grapnel rope would be only that of ten miles of cable. The result, therefore, of trying to raise a cable such as the Atlantic laid taut, would certainly be to break it; but cables are not laid taut in deep water, and the Atlantic is laid with a mean slack of about twelve per cent., and in the last days we may even count on fourteen or fifteen per cent. slack; that is to say, for every hundred miles passed over, one hundred and fourteen or one hundred and fifteen miles of cable were laid. Lay on the floor one hundred and fourteen inches of chain, between two points one hundred inches apart, lift it in the middle on a hook, the two ends will hang down in catenary curves, and when the cable at the extremities is just off the floor, the hook will be 23·3 inches from the floor. Quite similarly a cable laid with fourteen per cent. slack will, when caught by the grapnel, hang in two half catenary curves, and by the time 11·4 miles of the cable are off the ground, the grapnel will be two thousand three hundred and thirty fathoms from the bottom, *i.e.*, at the surface

TABLE VII.—*Giving length of Cable lifted with a given slack, and hanging in a catenary curve, &c.*

Slack in per centage.	Tension at highest point in terms of the weight of a length of Cable hanging vertically from the surface to the bottom.	Length of curve in terms of versine.	Length of versine of span 100.
0	Infinite.	Infinite.	0
1	47·6	19·42	5·2
2	20·8	12·75	8·0
3	13·5	10·20	10·1
4	10·0	8·74	11·9
5	8·18	7·84	13·4
6	6·90	7·16	14·8
7	6·01	6·64	16·1
8	5·39	6·24	17·3
9	4·88	5·92	18·4
10	4·52	5·67	19·4
11	4·18	5·43	20·45
12	3·89	5·21	21·5
14	3·49	4·89	23·3
16	3·12	4·58	25·3
18	2·89	4·37	27·0
20	2·67	4·17	28·8
22	2·48	3·98	30·6
24	2·39	3·89	31·9

TABLE VIII.—*Showing the length of a catenary curve of constant span equal one hundred, with various deflections at the centre, and giving strains at highest point in terms of the unit length of chain.*

Proportion of versine to span.	Length of versine or dip.	Length of curve.	Strain at highest point in terms of the unit length of chain.
0	0·00	100·0	Infinite.
$\frac{1}{12}$	8·33	102·1	160·9
$\frac{1}{11}$	9·09	102·6	149·3
$\frac{1}{10}$	10·00	103·0	137·6
$\frac{1}{9}$	11·11	103·4	125·8
$\frac{1}{8}$	12·50	104·3	115·2
$\frac{1}{7}$	14·29	105·4	104·3
$\frac{1}{6\cdot5}$	15·38	106·4	99·7
$\frac{1}{6}$	16·67	107·3	94·5
$\frac{1}{5\cdot5}$	18·18	108·9	90·5
$\frac{1}{5}$	20·00	110·4	86·2
$\frac{1}{4\cdot5}$	22·22	112·4	82·1
$\frac{1}{4}$	25·00	115·4	79·1
$\frac{1}{3}$	33·33	125·4	75·6
$\frac{1}{2}$	50·00	177·3	103·5

of the Atlantic. The strain on the grapnel rope will be the weight of the cable lifted, or about 11·4 miles; the strain on the cable itself at the point of suspension will be much less, being only about three and a half times the weight of the cable hanging vertically, or say eight miles of cable. (Observe that the strain on the cable and the weight of the cable are not synonymous. When the two ends hang plumb, the strain on the cable at the top is half the weight of the cable carried. When there is little slack, the strain is much greater than the weight carried.) If the depth were only two thousand fathoms, the strain on the cable when brought to the surface would only be equal to the weight of about seven miles of cable. Moreover, the actual cable is not held at any point except by its own weight, and there will be a pull at the bottom tending to haul in slack towards the grapnel amounting to several tons. But even without counting upon slack obtained in this way, it is clear that if the cable will bear eleven miles of its own weight, it could, under favorable circumstances, be hauled to the surface by a single grapnel.

Tables VII. and VIII. give the proportions and strains on catenaries in various convenient practical forms. Thus, from Table VII. we see that if ten per cent. slack be laid, the maximum tension on the catenary lifted in, say one mile, will be the weight of 4·52 miles of cable. In two miles depth the strain would be the weight of 9·4 miles of cable. In in the latter case, $2 \times 5{\cdot}67 = 11{\cdot}34$ miles of cable will be off the ground, and the grapnel rope must be strong enough to bear this. Table VIII. gives a similar information, supposing we do not start from a definite per centage of slack, but know the proportion of the dip made by a rope to the strain.

(To be continued.)

BLACK'S COMBINED ELLIPTIC AND CORRUGATED SPRINGS.

To APPRECIATE fully the merits of the combination above named, we must in the first place, understand the difficulties existing in springs of a different construction.

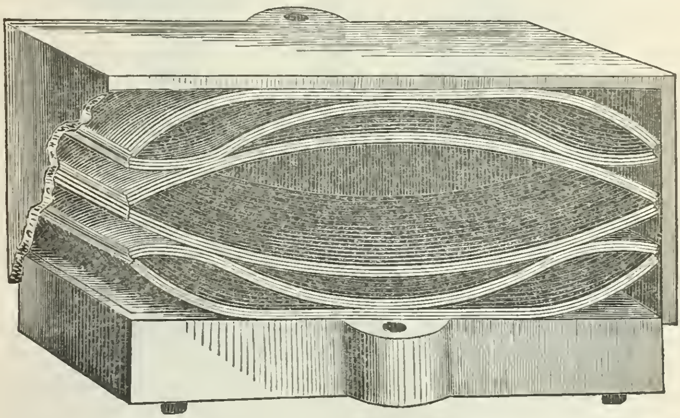
In the spiral spring, the elastic force of a single coil expresses the elastic force of the whole combination, and thus a weight capable of closing one coil will close any number. These springs have thus too little range of action. Being properly loaded with dead weight, a slight jar will close them, and they will become entirely useless.

To remedy this difficulty, spiral springs have been occasionally stuffed with wool, but this soon becomes packed and loses its elasticity.

The ordinary form of compound plate spring avoids this to some extent, by the arrangement of the plates, which, as the spring closes,

distributes the strain in such a manner, that the elastic force acting at greater advantage, offers an increasing resistance to the closing force. Thus, as the strain increases, the various blades of each half are flattened down upon each other, and as they come in contact they become practically united, thus producing a thicker and stiffer spring. But even here the remedy is not perfect, the maximum power of the central blades being the limit of available resistance.

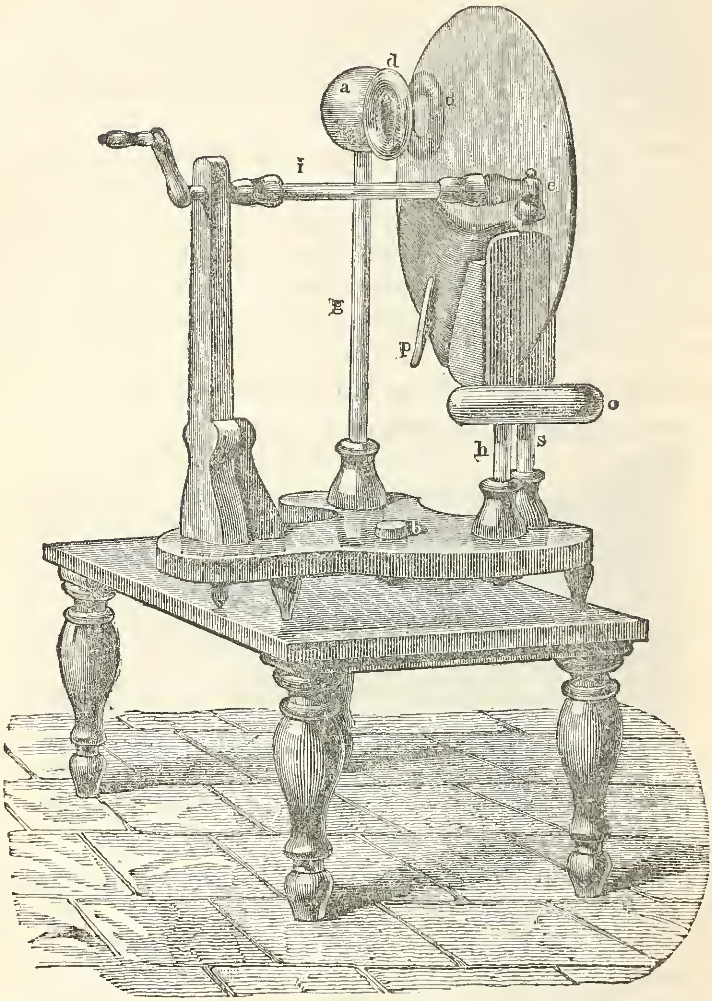
In another form, a system of corrugated plates alone is used. In this case, however, there are two difficulties. The pressure is applied at single points in the various plates; these do not vary during the compression, and therefore do not allow of that increase in resistance which would otherwise occur from a change in the number or position of the bearing point. In the second place, the spring thus produced, wants that delicacy under a light load which is given by a long spring, such as that of elliptic form used in the following combination:



In the case of the Combined Corrugated and Elliptic Spring, however, we see, that as the compressing force is increased, it first brings the corrugated plate, which is immediately over the elliptic spring, in contact with it at new points, so distributing the strain and increasing the resistance, and that even if the elliptic spring should be closed entirely, the corrugations of the plates would still continue to act as short, and therefore very stiff, springs; so that the range of action would, in this way, be vastly increased.

This combination may also be made to vary in delicacy or in strength to any degree, with great ease, by increasing the number of sets of springs and corrugated plates, for greater delicacy, and by increasing the number of elements in each set for greater strength; as by making each elliptic spring, and each corrugated plate, consist of several thicknesses.

Educational Department.



THE AUSTRIEN MACHINE.

LECTURES ON ELECTRICITY AND LIGHT.

DELIVERED BEFORE THE FRANKLIN INSTITUTE,

BY PROF. HENRY MORTON, PH.D.

It is my purpose, in the present course of lectures, to associate, as far as their natural relations would suggest, the phenomena of Light and Electricity. There is so much in common between these two, and

yet so much of difference in our ordinary conceptions of them, that an association, if natural and not too much constrained, may at least be of value as an aid to memory and a simplifying of ideas. For the sake of perspicuity and brevity, I propose to begin with the statement of such a theory as appears best suited to a popular treatment of the subject, and then will illustrate this by various explanations and experiments.

Before stating the theories which I propose to use, I wish to make some explanations as regards their scope, character and reliability. A theory may, if it is absolutely true, act as a guide to discovery, and lead directly, by applications of its dicta, to the knowledge of new facts. Good examples of such results are furnished in the discovery of the planet Neptune, by LeVerrier, on the basis of Newton's theory of universal gravitation, and in the prediction of Poisson concerning the diffraction of light, founded on the Undulatory theory of Huyghens.

Again, a theory, whether true or false, may be of great use as an aid to the memory, and to the mental conception of a complicated subject. It may serve, in fact, as a string, which will enable us to tie the facts together, and also to gather them easily into the hand.

A theory may possess both of these characters at once, or only one of them.

The first is the case with the now universal theory of light, the Undulatory or Dynamical theory. With regard to Electricity, however, we have not, as I think, any such fortunate hypothesis. The theory of Faraday, which can, perhaps, best lay claim to the first character of probable accuracy, is itself far too abstruse, involved and indefinite, to merit the latter distinction, and that of Du Fay, while admirable for its clearness and simplicity, does not impress us with a sense of its absolute reliability.

Being therefore obliged to make a choice under these conditions, and remembering that my office is not to guide you into new fields of labor and discovery, but rather to lead you, by the most pleasant paths possible, over the ground already won by stronger hands than ours, I have determined to employ that theory which will ask of us the least, and yield to us the earliest fruit; knowing, that even if subsequently it is to be abandoned, it will nevertheless have given us good assistance in its time, and, like a last year's suit, will be entitled to an "honorable discharge," even though out of fashion at this time. Though I make these limitations, I would not have you suppose that the theory to be presently stated is crude, improbable and unsupported by

the highest authority. It finds among its advocates and expounders, such names as De la Rive, Du Moncel, Becquerel, Daguin and a host of others, and finds *itself* in discord with no fact yet observed. These preliminary matters being disposed of, I will now proceed to the statement of the Double-fluid theory of Electricity first suggested by Du Fay, which may be made very clear and easy of comprehension, we think, by aid of an illustration.

The air, as you know, is not a simple substance, as the ancients believed, but is a mixture of two very opposite gases; one of them, Oxygen, being the most active of the elements, supporting and stimulating combustion, and concerned in almost every action of light and life; the other, Nitrogen, so opposite in all respects to this, that it has received among the French (and well deserves) the name of "Azote," or "lifeless."

These two, mingled as in the air, exhibit neither of their peculiar properties in a very strong degree; but, when separated, each shows its own in a marked manner. Again, though as a matter of fact these two gases do *not* readily combine, yet, for the sake of our illustration, we might easily suppose, that like many other dissimilar gases, they would unite with violence. If so, their union would, like that of other gases so combining, produce a violent motion of the surrounding air, such as we call a detonation, or sudden loud sound. This sound would finally be transmitted by the combined or mingled fluids, or by either separately. Sound, as you know, travels well in any gas.

Now, according to our theory of electricity, there is a fluid, or gas, extremely light and rare, pervading all space and all matter, which like the air, is made up of two different fluids, very distinct in some of their properties, though alike in others. These, when mingled or combined, neutralize each other, but each separated, shows its own powers in a clear manner. The chief properties of these fluids which we need now notice, are their attraction for all that is unlike, and repulsion for all that is like, themselves.

Thus, the particles of each fluid are mutually repellant, but attract those of the other fluid and matter generally. These fluids, again, travel freely through some bodies, such as metals, and are resisted in their passage over others, such as glass and shellac, and when they meet, combine, often with such violence as to cause those vibrations in the surrounding medium, which we recognize as light.

Lastly, this surrounding medium may be composed itself, of the

combined or mingled fluids, and transmit the shock of their union, as water does that of an explosive mixture of Oxygen and Hydrogen, or as air would that of its constituent gases, did they unite with energy.

Such being the ideas which we would propose, as affording a tangible basis on which we can build up some simple notions of electric force and its relations with light, we will proceed to the further discussion of the facts, in connection with the above general theory.

Assuming the existence of two light mobile fluids, which only exhibit their distinctive or electrical properties, when separated in some way, we find that three kinds of separation may be effected, and will give rise to three kinds or classes of phenomena.

In the first place, the fluids may be so separated that greater or less quantities of each may be accumulated and retained in different bodies. The phenomena which result from this condition, are known as those of Statical Electricity.

In the second place, the fluids may be so affected as to be set in motion in opposite directions, through a closed circuit, thus giving rise to Galvanic phenomena.

Lastly, such an action as the last may be established in the individual molecules of certain substances, and we then have Magnetic properties developed.

These various actions we will study in their order.

Statical Electricity.

When two substances are rubbed together, their natural charge of electric fluids is so separated, that an excess of one kind will accumulate in one body, and an excess of the other kind in the other substances.

Thus, this piece of amber, being rubbed with this woollen cloth, the positive fluid collects in excess in the cloth, while the negative in the same degree accumulates in the amber.

To prove this, I have recourse to an instrument, whose action is based upon the first property of the electric fluids already expressed, namely, that particles of the same fluids repel each other.

We have a glass flask, within which are suspended by a brass rod two strips of gold leaf. A plate of brass terminates the rod above.

Having "excited" the amber by rubbing, as before stated, we place it upon the brass plate, when at once, the gold leaf strips diverge, as is shown in the figure; thus proving their mutual repulsion and the presence of one electric fluid in excess. Then, removing the amber, and putting the woollen cloth in its place, we first find the

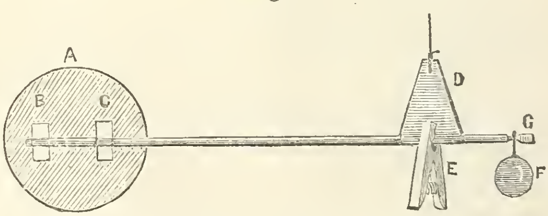
leaves collapse, because the fluid in them is neutralized by the opposite sort coming from the cloth, but then again expanding from an excess of the positive fluid, if the cloth is made to supply a sufficient amount.

In the apparatus as below figured, there is sometimes a difficulty, from the adherence of the gold leaves to the glass, when they diverge enough to touch it. This may be avoided by coating the interior, at these points, with some conducting substance in connection with the ground, as by silvering the lower part of the flask, and boring a small hole through the bottom, by which a strip of tinfoil may pass to the interior, or by cutting out the whole bottom, and then pasting strips of tinfoil where the gold leaves would strike, or the apparatus may be made from a small bell jar, similarly provided.

Fig. 1.

Another yet simpler piece of apparatus may be used for a like purpose. From some convenient support we suspend a straw, a fine glass tube or thread of shellac. At one end of this is a little ball of pith, and at the other a counterweight of tea lead, tinfoil or the like. If the excited amber is brought near to the ball, this body will be attracted by the excess of electricity in the amber, but after contact will be repelled; the amber and ball

Fig. 2.

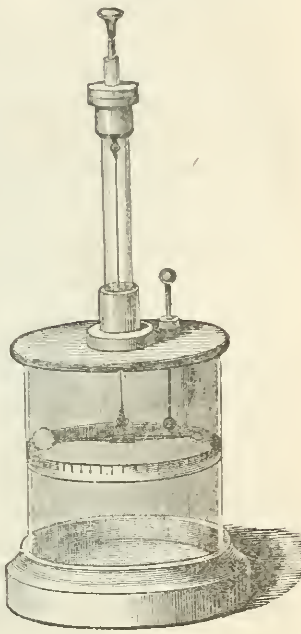


then both having the same kind, but in this condition the ball will be powerfully attracted by the cloth with which the amber was rubbed, this containing, an excess of the opposite fluid.

On the large scale, the pith-ball of the instrument above described

may be replaced by a disk of card, A, fastened to the glass tube by staples of paper, and varnished with shellac on its edge. The glass rod is supported in a stirrup of paper, D, and is prevented from slipping by a patent clothes-pin, attached as in the figure at E. To effect repulsion after contact, we must then have some large excited body, such as the plate of an "electrophorus," to be described subsequently.

Fig. 3.



When a small instrument, such as that first described above, is inclosed in a glass case, through which passes a brass rod and ball, by means of which an excited body may convey its action to the suspended pith-ball within; it forms a very delicate indicator of electricity, and is known as Coulomb's Electroscope, or, when the supporting filament is of wire, whose torsion may *measure* the repulsive force between the brass and the pith-balls, Coulomb's Electrometer. Its form is shown in Fig. 3.

By means of these various instruments, it is easy to illustrate the fundamental facts of Statical Electricity.

1st. We prove, by rubbing together all sorts of substances, and then applying them to these various instruments, that opposite fluids are invariably developed at the same time, and that all bodies are capable of this action. But we must take the precaution of insulating good conductors, such as metals, from the hand by glass handles, silk cloths and the like, or we shall lose into the ground the electricity developed, before it can be brought to the machine. If, in a dry, warm room, during cold weather, the finger is placed on the plate of the Gold-leaf Electroscope, Fig. 1, and the foot is drawn over the carpet, the leaves will diverge, and, under favorable conditions, sparks may even be given off from the hands, so as to ignite the gas at a burner; thus showing how easily electricity is developed by friction. Success in this and most other electrical experiments, depends upon the dryness of the air and of the apparatus used. Damp air and moist surfaces, carry away electricity as fast as it is developed. Thus, in the warm summer weather, when the air is full of moisture, all experi-

ments fail, not because no electricity is produced by our manipulations, but because it is all lost before we can use it.

The low temperature of the air in winter prevents it from holding so much vapor, and thus it is itself dry, and renders dry all apparatus exposed to its action. The common idea of a greater amount of electricity in the air in winter than in summer is then, not a true one.

The total *amount* of the fluids present in all bodies is invariable under all conditions; the changes we observe are only in the relative quantities of the two kinds. A positively charged body has more positive fluid than one not charged, but then it has as much less negative, for when rubbed with another to produce that excitement, the other acquired negative electricity, while the first secured positive. Thus, let

| + — + — | represent two bodies in their natural state, then after
| + — + — | friction they will be indicated thus, | + + + + |
when each has as many particles in it as before, only | — — — — |
these are now all positive in one, and all negative in the other.

2d. We find, by the same means, that the capacity for accumulating one or other of the opposite electricities, is not absolute in different substances, but relative; so that various kinds of matter cannot be separated into classes, one capable of developing the positive and the other the negative fluid, but must be arranged in order or series, beginning with the most positive, ending with the most negative, (or *vice versa*.)

Thus, any body in such a list or table, rubbed with one below it, will develop positive; with one above it, negative electricity.

Thus, in the following list, silk rubbed with sulphur acquires positive electricity; with smooth glass, negative electricity.

Table of some substances in their Electrical Relations.

MOST POSITIVE.—	Fur,	Paper,
	Smooth Glass,	Silk,
	Woollen Cloth,	Lac,
	Feathers,	Rough Glass,
	Wood,	Sulphur.

MOST NEGATIVE.—Gun Cotton, and like bodies.*

* The cuts in this article, except Fig. 2, are entered according to Act of Congress, in the year 1861, by J. B. Lippincott & Co., in the Clerk's office of the District Court of the United States, in and for the Eastern District of Pennsylvania.

THE MAGIC LANTERN

AS A MEANS OF DEMONSTRATION.

Conservatism seems to have been the characteristic of ancient science and civilization, but modern progress, on the contrary, has for its most conspicuous feature, a generous and unlimited diffusion of its treasures and acquisitions, among all. Especially is this manifest at the present time, when the deepest and most successful students of nature, find their greatest fame in the successful manner in which they have exhibited and made clear to the general public, the most momentous results of their labors. Witness Faraday's Lectures on the Physical Forces, and on The Chemistry of a Candle—Tindall's various lectures—those of Hoffman, Crace Calvert and many others too numerous to mention.

Under these conditions any instrument which largely assists in exhibiting to many at once, what must otherwise be confined to the close inspection of a few, and thus renders possible, the visible demonstration of a fact which must otherwise be only stated, is at once so eminently useful to the man of science in his relations with the *now* scientific public, and so in tune with the temper of the time, as to merit much attention and some study.

Such an instrument is the Magic Lantern in its improved form, now familiar to all; and it is with a view of putting on record some useful experiences which may avail others, and of inducing a more general employment of this instrument for the ends it is so eminently fitted to serve, by which its very efficiency will be itself increased through improvement and discovery, that the following pages have been prepared by one who has had many years of practical acquaintance, with the instruments and manipulations which he describes.

It is proposed to treat the subject in as thorough a manner as possible consistent with a purely practical view, spending no time over historic details and preliminary discussions, but going at once and fully into the *minutia* of manipulation and construction. We propose to describe the best means known to us, of preparing and storing the gases used for the light; the structure and management of jets; the arrangement of lanterns for different purposes, including the Gas-microscope

and Polariscope; the structure and management of various pieces of apparatus used with these; the means by which all optical laws may be demonstrated, and the operation of the electric and magnesium lights, and their scope of application.

Preparation of Oxygen Gas.

As yet no process has been devised, which meets the various requirements of the present demand for oxygen under existing conditions, so well, as that in which chlorate of potash, and black oxide of manganese are heated in a close vessel. The only subject worth discussion is therefore the character of the vessel and the method of heating. In these connections, however, we think that we may say something which will be useful and new to many.

The simplest process, as regards means and appliances, is that first suggested, as we believe, by Dr. Wilkinson, of New York, and frequently employed by him in the laboratory of Dr. Doremus. This consists in taking an iron tea-kettle, placing in it the mixture of chlorate and black oxide ($KOClO_5$ four parts, MnO_2 one part) luting on the cover with clay, or plaster of Paris, and securing this in position by a stick between it and the handle, connecting the spout with a large reservoir, tilting the kettle backwards on a large gas-stove or small furnace, and so driving off the gas. With several pounds of material, the gas comes off in terrible haste, but with perfect safety, as, long before any dangerous pressure could be reached, the handle would give way and open a thoroughly efficient safety-valve, namely, the lid of the kettle.

Next to this comes the usual **iron retort** about which there is little to be said, except that it requires a good fire to heat it, and cannot be managed with a common gas-stove or Bunsen burner. With a large Argand burner and steam blast it, may however, be heated sufficiently. For this purpose we provide a closed copper cup, capable of holding about one pint, and fitted with a tubular at the side for filling, and a fine jet at the middle of the top. Above and around this jet, is supported a large Argand gas-burner. A few ounces of water being introduced into the copper cup or boiler, the tubular is closed with a cork, and an alcohol lamp is placed below. When steam escapes freely, the gas is turned on and ignited, and a blast-lamp of great power is thus produced. The escape of oxygen from the iron retort being once fairly started, the heating apparatus may be removed, and the process will then finish itself.

The copper flask should next be noted. In this case, a "chemical lamp," gas-stove or Bunsen burner will give sufficient heat, and for this reason, as well as on account of its lightness and portability, this form of oxygen generator is much used.

We observe that many experimenters find a tendency to sudden and violent action characterizing these flasks, and we have ourselves experienced some trouble from this cause, but we think the difficulty may be avoided by the following means:

Use a mixture, as above, of four parts chlorate to one of black oxide, and then heat promptly and rapidly until the gas comes over freely; then remove the heater, but replace it again if the action slacks, removing again, of course, when this becomes rapid.

The violent action occurs, we think, when, from too gradual a heating, the whole contents of the flask is raised nearly to the point of decomposition before any part is decomposed, then when the action begins at any point, the heat developed causes it to extend at once throughout the mass.

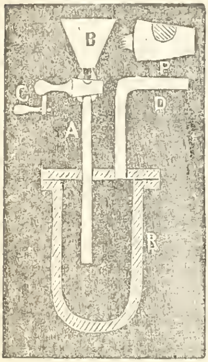
By rapid heating, on the other hand, the lower layers are decomposed before any heat reaches those above, and the action is thus successive and moderate; not constantaneous, and almost explosive.

The grinding process as it is commonly called, is very efficient, and, where very large quantities are to be worked, is almost essential. In this case we have an ordinary iron retort, R, (Fig. 1,) through the lid of which pass two iron pipes, one, D, the delivery tube, the other, A, having at its upper end a stop-cock with a plug, not perforated, but having a hollow or cup in it, as shown on the large scale at P. This plug has a handle or winch, and above it is a large tin funnel, B.

The retort being heated in a furnace, chlorate of potash is placed in B, and the handle, C, receiving one turn, as much of the salt as the cavity in P, holds, is allowed to fall into the retort. Another turn gives a fresh supply. A wash-bottle placed beyond D, enables the operator to see that the salt is being decomposed as it is introduced, and is not accumulating in the retort. This is the process used by Grant, of New York. He has a gas-holder of one thousand gallons capacity, which he charges in this way, and then pumps the gas into the iron reservoirs. A good modification of the above is that made and used by Mr. Debeust, assistant to Professor R. E. Rogers of the University of Pennsylvania, in this city. In this there is substituted for the funnel, B, a cylindrical hopper, closed above by means

of a screw-plug, and for the cock, C, a small wheel with wings or buckets. The whole quantity of chlorate to be treated, is placed in the hopper, which is then closed air-tight by the plug; then on turning the little wheel the salt is delivered piecemeal into the retort. The advantages are, that the wheel need not fit air-tight at first, and that no loss by leakage can occur, as with the other form, if the cock is worn.

Fig. 1.



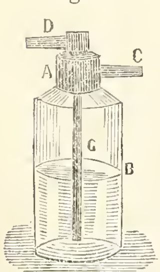
This concludes all we can say from our own knowledge about apparatus for making oxygen. We should however, here mention a few precautions worthy of attention.

To make sure that the black oxide of manganese used is pure, and even, in fact, the substance named, and not sulphide of antimony or the like; mix a few grains with chlorate of potash and heat in a test tube. If a violent burning or explosion occurs, you have lost a test tube but perhaps saved your life, and will, of course, not use the dangerous material. If the gas comes off quietly, with a few minute sparks or glowing of the material towards the last, all is right.

The proportion of oxide and chlorate given above, *i. e.*, one part black oxide of manganese to four parts chlorate of potash, is a good one, but may be varied much either way without injury. The less oxide used the greater the chance of sudden action.

One pound of chlorate will yield about thirty gallons of oxygen, or will fill a thirty by forty inch gas-bag, made of pillow-shape. If the gas-bag is thirty by forty inches and of bellows or wedge-shape, it will take about one and a quarter pounds of chlorate to fill it full.

Fig. 2.



If the gas is to be run directly into gas-bags, it should be washed as thoroughly as may be, by means of wash-bottles, of which Fig. 2 shows a good form.

The brass cap, A, is cemented to the neck of a quart bottle, B, and has in it a tubular or outlet tube, C, for the escape of the gas, and another opening above, in which is fitted, by grinding, the bent tube, D G, by which the gas enters. The lower end of G, is pierced with a number of holes by which the gas escapes in minute bubble and is thus better washed. D G, is easily withdrawn, when the water is to be emptied out or replaced.

Franklin Institute.

Proceedings of the Stated Monthly Meeting, December 19th, 1866.

The meeting was called to order with the President, Mr. William Sellers, in the chair.

The minutes of the last meeting were read and approved.

The Board of Managers presented their minutes, and reported, that at their Stated Meeting, held on the 12th inst., they elected forty-four new members of the Institute, and eighteen new names were proposed for election at the next meeting.

Donations to the library were received from the Institution of Civil Engineers; the Institute of Actuaries; the Statistical Society; the Society of Arts, London, and the Literary and Philosophical Society, Manchester, England; the Royal Irish Academy, Dublin, Ireland; l'Ecole des Mines, Paris, and la Société Industrielle de Mulhouse, France; the K. K. Geologischen Reichsanstalt and the K. K. Geographischen Gessellschaft, Vienna, Austria; the Board of Water Commissioners of Jersey City, New Jersey; and Prof. H. Morton, of Philadelphia.

Mr. J. Vaughan Merrick announced the death of Mr. Thomas Fletcher, when the following preamble and resolution were adopted:

Whereas, The death of Mr. Thomas Fletcher, who was prominent as one of the associates of the founder of the Institute, has occurred since the last meeting of this Board; therefore be it

Resolved, That official notice of the loss thus sustained by the Institute be made at the next meeting thereof, in order that suitable action may be taken.

The various Standing Committees reported their minutes.

The Special Committee on Experiments in Steam Expansion reported progress.

There being no report from the Special Committee on General Totten's letter, relative to the establishment of a Government Bureau of Mechanical Examinations and Experiment, this Committee was by motion, duly carried, directed to report at the next meeting, being subject to discharge according to Article X., Section 3, of the By-laws.

The Special Committee appointed to collect statistics, concerning the history of the Institute, reported progress.

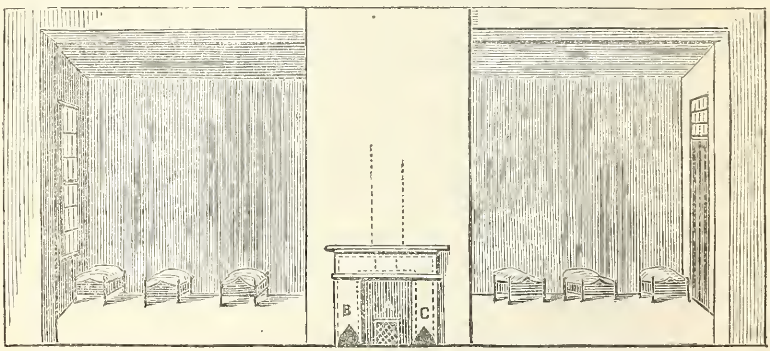
The report of the Resident Secretary on novelties in science and the mechanic arts, was then read as follows:

Secretary's Report.

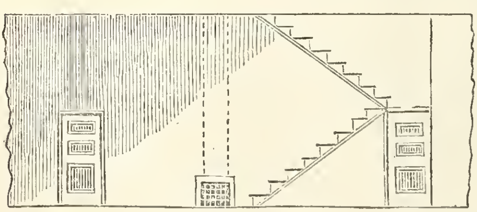
The experiments in warming and ventilating the Philadelphia Almshouse, lately perfected, have met with the most signal success, as we see from the report of Mr. J. M. Whithall, Chairman of the Committee having this matter in charge, (an extract from this report relating to the above, will be found on page 14 of this *Journal.*) We there see, that the ventilation being secured by special flues opening from the *lower part* of the various rooms, and in each case independent, all offensive odor was avoided, the average health of the inmates decidedly improved, and in the case of the cholera and fever, a marked check was given to the spread of the disease, and a speedy recovery effected in those attacked.

The exact arrangement employed, is shown in the accompanying cuts.

The first represents one side of a room, showing the opening for the introduction of hot air at A. The flue by which this comes up, is here abruptly shut off, and the ventilating flues having openings at



B and C, pass up through the sides of the mantle-piece, and uniting above, pass out through the roof by the upper portion of the regular flue or chimney. The second cut shows the plan which has been adopted in the



corridors and stairways, where special flues have been constructed. On the occasion of a late visit paid by the Secretary, to the building above named, in company with Messrs. Geo. Erety and L. W. Leeds, the results observed were of the most surprising and satisfactory description. Rooms entirely closed and

occupied by many persons, being, by means of the arrangements above described, kept in a remarkably fresh and inoffensive condition.

The philosophy of this method and its relative efficiency is, we think, easily explained. The warm air driven into the rooms by the heating apparatus is, of course, pure; it equally, of course, rises on entering the apartment, and fills its upper portion. If it is there allowed to escape by a ventilator near the ceiling, it passes out again without having much effect upon the mass of air in the room, which remains stagnant, unchanged, and becomes, by the use of the inmates, very impure. If, however, the only outlet is at the floor, it is the *colder* air which has been longest in the room which goes out, the fresh, warm air gradually taking its place, and thus a regular and complete displacement and circulation is effected, by which means, a warmer temperature is secured with an equal supply of hot air, and the various advantages already enumerated are obtained.

Such a view as above, we think, fairly expresses the actions concerned, without any regard to the effects which are sometimes imagined to result, from the great density of carbonic acid, which, owing to the very dilute condition in which that gas is expired from the lungs, and the rapidity with which it diffuses in the surrounding air, are incapable of producing any practical influence in the present relation. The question, we believe, is not *which part* of the air is taken out, but how to change, in a regular and continuous manner, *the entire mass* of air. Similar results to those mentioned in the above-named report were observed in the case of the New York Poorhouse, on Blackwell's Island, where the cholera, after showing itself with great virulence at first, (some one hundred cases at a time,) was entirely exterpated in five days by a judicious system of ventilation, combined with corresponding treatment, such as exercise in the open air and the like.

Steam cultivation in England.—Mention was made in a previous report, Vol. LII., page 350, of the facts observed in this relation in one part of England, by Mr. Edward Brown, and we now find in *Engineering*, page 379, further statistics and numerous returns from various places, all tending to demonstrate the practical success of these applications. Thus it appears that the average cost of cultivation or plowing, exclusive of interest, repairs &c., is from 3*s*. to 4*s*. 6*d*. per acre. The sources of expenditure above excepted, form however, a heavy item, and when a liberal allowance is made for them, as in the report by Mr. E. L. Betts, with regard to the use of steam on Preston Hall

Farm, Aylesford, the cost of cultivation reaches 10*s.* 3*d.*, and of plowing 14*s.* 4*d.* per acre. Even at this rate, however, the work appears to be economically performed.

Improvements by dredging in the river Tyne have been in progress for many years, and are now in an advanced state. The actual amount of material removed, is about fourteen million of tons, at a cost of about 3½*d.* to 4*d.* per ton, exclusive of machinery, of which enough has been provided to take out four million five hundred thousand tons per year. The sum expended in this work will give some idea of its magnitude. This has already reached over $4,000,000, and it is estimated that nearly $2,000,000 more will be required for its completion. The whole river will then be excavated, so as to yield a depth of fifteen feet at spring low tides.

The Southwark and Vauxhall water-works for London, are distinguished by some peculiarities which may be of interest, and of which we find an account in *Engineering*, page 377. The water from the Thames at Hampton, is admitted into a subsiding reservoir having an average capacity of five million gallons, from which it is pumped by direct-action engines, thirteen miles to Battersea, where it first accumulates in two subsiding reservoirs, from which it passes through filter-beds, and is then pumped into the distributing mains.

The engines at Hampton, pump into a thirty-six inch main against a head of one hundred and thirty-five feet, in a stand-pipe, by which the flow through the thirteen miles is maintained. The filter beds at Battersea are five in number, and have an aggregate area of nine acres. The water enters each of these at the centre, and is collected from a system of branch-drains built of brick with open joints. The capacity of the filter is found to depend very directly upon the extent of these drains, their effect being limited to a narrow lateral area, so that outward flanging-banks add to the cubic capacity but not to the filtering power of these basins. The beds of the filters are lined with concrete, one foot thick; on this is placed the filtering material as follows: Twelve inches of boulders, six inches of coarse gravel, six inches of fine gravel, six inches of hoggin, and then three feet of Hardwhich sand. A head of water averaging four feet is kept upon these. The sand is from time to time, washed in an iron cylinder with a perforated false bottom, through which the water rises from below. During the month of July, the average daily supply of water thus treated was twelve million one hundred and eighty thousand gallons. Five pumping engines are used at Battersea to supply the high level service.

The lake tunnel to supply Chicago with water, is now finished, the actual opening between the two galleries, one from the land, the other from the lake end, having been made in the presence of the Board of Public Works on the 17th of December. This work, from its entirely original and daring character, deserves a thorough record, and we hope before long to obtain full details; in the meantime we may note a few prominent facts.

This structure was designed and executed by E. S. Chesbrough, City Engineer of Chicago. It was begun on March 17th, 1864, and has been steadily advancing ever since. The formation through which it passes, is a stiff clay, containing boulders of porous calcareous stone charged with petroleum, and occasional pockets of sand. One of these caused the engineer above named, a very serious alarm. One morning some of the workmen came before daylight to his house with the news that the water of the lake had burst into the end of the gallery. He hurried to the spot, and descending the shaft, found, to his great relief, no water there. This, of course, showed some mistake on the part of the workmen, and on further examination, it appeared that they had struck a pocket of sand charged with water, which had caved in, and they had escaped for their lives, with such celerity, as not to recognize the true nature of the accident.

In June, 1865, an immense crib, ninety feet in diameter, forty feet deep, intended for the outer end of the tunnel, was towed into its position and lowered, by being filled in with stone in some of its compartments, until it rested on the bottom, two miles from the shore. A cylindrical iron caisson was then forced down in its centre, where an opening had been left for the purpose, and when this had reached the required depth, a gallery was run towards that, which was approaching from the shore.

The above rough outline is chiefly collected from notices in the daily papers, but we hope soon to publish a full account with accurate drawings, from head-quarters.

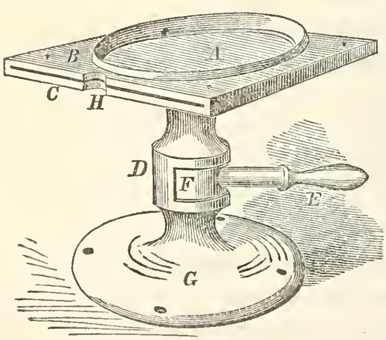
A centrifugal pump of Appold's pattern, was lately tried at the Minotaur graving dock and the steam basin at Portsmouth Dockyard. The indicator diagrams showed an amount of power expressed by three hundred and thirty-three horse-power, while the work actually done by the pump was equal to two hundred and twenty-four horse-power, in the same time. We thus find the efficiency of the pumps to be represented by sixty-seven per cent. of the total indicated force in the engines.

These pumps are coming largely into use, and seem to be both efficient and economical.

Nitro-glycerine has been used for blasting, extensively, in the stone quarries of the Vosges, near Saverne, by MM. Schmidt and Dietsch. The explosive material is made on the spot, pouring concentrated glycerine into a mixture of one part, by weight, of nitric acid with two parts sulphuric, which has been previously cooled and is kept cool during the operation. The whole material is then poured into cold water, and, after being rinsed and decanted, is ready for use. The little acid and water which the nitro-glycerine retains when thus prepared, would be fatal to its keeping qualities, but is of no account when it is to be used at once. The proper charge of nitro-glycerine being poured into the hole, a little tin case of powder is let down into it by a fuse, and the rest of the hole filled with sand. When the case of powder explodes, its concussion causes the nitro-glycerine to detonate.

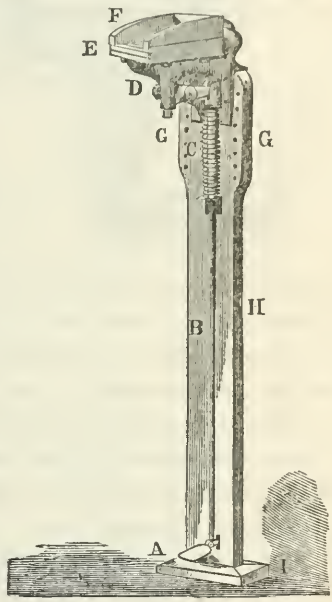
In the open quarry no ill effects are found to result from the fumes of this substance, which produce violent headache when inhaled; but in the headings of mines this would be likely to become a serious difficulty.—(See *Journal of the Society of Arts*, page 726.)

The Photograph cutter of Theodore Bergner, was next exhibited and described. The ordinary method of cutting out photograph prints, to an accurate size and shape, by means of a knife and template, is one of the most irksome manipulations connected with professional photography, and of various devices that have been contrived with the object of superseding this slow and imperfect method of cutting, that



exhibited to-night by Messrs. Wilson & Hood, is the most ingenious and practically useful one. It is the invention of Theodore Bergner, and has been for some time in use with most of the leading photographers in this city, who have practically tested its durability, and its accurate and expeditious manner of working. It has no knife-edged cutter, but the picture is cut out by a punch and die, producing a keen shearing cut; and a main peculiarity in its construction, consists in the reversion of the ordinary method of applying the punch, which in this case, produces the cut by entering the die from below, thus exposing

to full unobstructed view, the picture to be cut, so that it can be conveniently and accurately adjusted, before the punch is moved upward to cut it out. The paper is inserted in a shallow space between the die and another similar plate below it, which lower plate is a correct guide for the punch, and also serves to strip from it the paper out of which the picture has been cut. The mechanism for actuating the punch, is not the same in the large instrument as in the smaller ones, but very simple and efficient in either case. In the large cutter the stem carrying the punch extends downward through the stand, and is provided with a coarse screw-thread, fitting a corresponding female thread, in the hub of the hand-lever. The oscillating motion of the lever gives a sufficient vertical movement, and great power to the punch. In the small cutter, the stem of the punch has a notch cut in it, like the space between the teeth of a spur-wheel, and into this notch is fitted a tooth provided on the small transverse rock-shaft. The vibration of this rock-shaft, by means of a rod and treadle, actuates the punch in the required manner. This invention has been recently applied with success, for the cutting out of the large round revenue stamps, which brewers are required to attach to the barrels in which malt liquors are sold, one of the instruments exhibited, being of the kind used for this purpose.

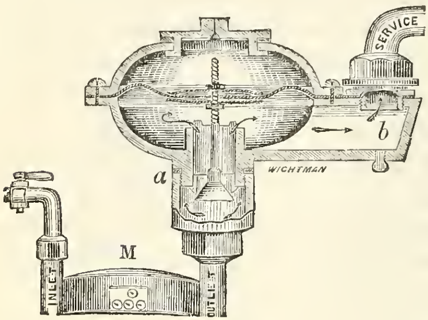


These various machines were exhibited, and their operations shown.

An apparatus to indicate the depth of water in a ship's hold, by T. S. Speakman, Esq., was next exhibited. Its structure and action is as follows: A large copper pipe is firmly attached in a vertical position to the kelson, or flooring of the ship. Within this is placed a large cylindrical copper float, water being admitted to the inside of the cylinder from without, by numerous apertures, covered with fine wire gauze, by which means, any sudden change of level in the inside, such as might be produced by the rolling of the vessel, is avoided. From the float a thin metallic rod is carried up to the captain's cabin or other convenient place, and there by a scale, at once indicates the level of water in the hold, at any moment.

An apparatus for the preservation of ship's timbers was also exhibited by the same gentleman as above. This result is reached, by circulating fresh sea-water around the kelson, and thus, from time to time, rinsing out the bilge-water.

The Leffingwell gas regulator was next exhibited. This instrument consists of a circular iron vessel, divided across the middle by an elastic horizontal diaphragm, and having in its lower part two passages, an inlet, *a*, and an outlet, *b*. The inlet is connected directly with the gas-meter, M, and the outlet with the service-pipes. The flow of the gas in inlet, *a*, is controlled by a conical valve whose stem is supported by the diaphragm, and which thus varies in position with the rise and fall of that part. Thus, when the pressure in the service-pipes increases by the sudden shutting off of burners, the diaphragm rises and partially closes the valve, so as to cut off the supply; when, on the contrary, the pressure decreases, the diaphragm falls, so opening the valve and giving a freer passage to the gas. The advantages claimed in this form of instrument over others, are its cheapness of construction and ease of management, while it yields to none in practical efficiency.



Small working models of locomotives and other steam engines, from J. W. Queen & Co., were then exhibited in action. Their peculiarity consists in great simplicity of structure, by reason of which, they could be made at so cheap a rate as to become toys, while, at the same time, their working was most efficient, (a little locomotive with its tender, ran across the laboratory table, twenty feet long, so rapidly as to need quick following to save it from a fall at the end.)

Spectrum analysis of stars, by Father Secchi.—This author, in a paper read before the French Academy, divides the stars, as regards their spectra, into three classes: 1. White stars, showing a strong band in the green-blue, (Franenhoffer's line F.) Another, a little in the violet a little short of G. About one-half the stars are of this type. A few exceptions, however, occur thus, ζ Cassiopeiae, and β Lyrae, though white stars like the rest, show bright lines in place of these dark ones, while all the stars of Orion, except (a) show very fine bands

in the place of these heavy ones. These stars of Orion, are in fact, unique; none others in that portion of the heavens, are found like them. 2. Redish stars with bright bands in the red and orange. Examples of this class are found in α Orionis, α Tauri Antaris, β Pegasi, α Herculis &c. In the last of these, the spectrum looks like a row of colored columns illuminated from one side. 3. White stars, with many fine lines, corresponding to those found in the sun, which in fact belongs to this class, together with Arcturus, Capella, Pollux &c.

The solar line B is due to carbonic acid, according to Angstrom, who found that it remained with undiminished intensity at Upsal, with a temperature of 16·0° F., when the aqueous lines generally were obliterated.

The relations between the wave lengths of absorption bands in the spectra of elements, have been elaborately studied by Gustave Hinrichs, and made the subject of a voluminous paper in *Silliman's Journal*, (Nov. 1866, page 350.) Some of his most interesting conclusions are the following: That the wave lengths corresponding to the bands in each elementary spectrum, differ, by a fixed number or some simple multiple of the same, or, in other words, that if we suppose lines to have been made at regular intervals, and then some of them obliterated, the actual condition now existing would be reproduced.

That the dark lines are produced by a certain interference.

That they are the result of, at most, three systems of interference.

That the lines generally are closer, the greater the atomic weights of the elements.

That the distance of the lines is also related to the atomic dimensions.

The character of electric discharge in rarified gas, and the cause of stratification in the light so produced, has been made the subject of an interesting publication by De la Rive. His conclusion is, that the stratification is due, like the sonorous wave, to a regularly recurring variation, in a series of vibratory impulses, by which lines or surfaces of various density are established in the rarified medium. The electric discharge meeting with more resistance in the denser parts, there develops more light. He also shows that the dark spaces become less heated. For further particulars, see *Chemical News*, page 190.

An ice machine on Carré's plan is said to be in very successful operation at Schreveport, Louisiana, making eight thousand pounds per day, and yielding a large profit to those working it.

A process of inverse filtration, by M. Carey Lea, of this city, is described in *Silliman's Journal*, page 380, and promises to be very useful in certain cases. A piece of muslin, with or without filter paper inside, is secured over a glass funnel, and the latter is then inverted in the vessel of liquid to be filtered, an india rubber and a glass tube being attached to the stem of the funnel, so as to convert the whole into a syphon, which being filled with water, will draw the liquid through the muslin &c., thus filtering with considerable rapidity, if desired.

Sulphate of barium as a substitute for white-lead is now largely used for the glazing on paper collars. Twenty tons (?) per day are said to be so used in New York.

An immense deposit of pure rock-salt has been found at Pahranagat, in Nevada, the mineral being in many cases of perfect transparency.

The English practice in construction of blast furnaces, seems to be going in the direction of increased size and a higher temperature. Dimensions of twenty-five feet at the boshes and eighty feet in height, and temperatures of one thousand and fifty degrees and eleven hundred degrees, are employed, with marked economy and no drawback from the crushing of the charge and "gobbing" of the furnace, (*i. e.*, choking with dense mass of material impervious to the blast.)

The Rosedale and Ferry-hill Company are even about to blow-in a pair of furnaces, twenty-seven feet in the boshes and one hundred and two feet high. The result of these changes has been to reduce the consumption of fuel to so little as twenty-one hundred weight for each ton of pigs, made from an argellaceous ore containing thirty-one per cent. of iron. For further particulars on this subject, see *Engineering*, page 400.

Deferred business being then in order, it was moved, in accordance with a resolution carried at the previous meeting, that a committee be appointed by the President, to draw up a memorial to Congress relative to the establishment of an uniform code of danger signals, throughout the United States. This motion was duly seconded and carried.

New business being next considered, the following preamble and resolutions were offered by Frederick Fraley, Esq., and adopted by the Institute:

Whereas, Thomas Fletcher, one of the associates of the founder of the Franklin Institute in bringing it into organized and useful existence, departed this life on the 14th day of November, A.D., 1866,

after a long and useful career; therefore, for the perpetuation of the memory of such a man, it is

Resolved, That we shall ever cherish in our grateful remembrance, his services as Treasurer and Vice-President, and the hearty zeal which, during his active membership, he manifested for every measure that would promote the usefulness and prosperity of the Institute.

Resolved, That while we sympathize with his family in their bereavement, we feel assured, that as he had filled the characters of parent, friend and citizen, for a period rarely allotted to man, in a way honorable to himself, their grief will be solaced by the many memories of his work.

Resolved, That the Secretary transmit a copy of these proceedings to the family of Mr. Fletcher.

A letter from Prof. John F. Frazer, resigning his office as Vice-President of the Institute, was read by the Secretary, and, on motion of Frederick Fraley, Esq., it was

Resolved, That the Institute receives with regret the resignation of Prof. Frazer, and that its members desire to express their sorrow that ill-health should withdraw him from those duties and services, for whose performance in past time they wish to tender their sincere thanks.

Resolved, That the Secretary be directed to communicate to Prof. Frazer the above resolution.

On motion of Coleman Sellers, Esq., the meeting then went into nomination of officers and managers for the ensuing year.

Mr. Wm. Sellers being re-nominated for President, announced that he desired to withdraw his name as a candidate for re-election. Although sensible of the honor conferred by the preference so far shown him by the members, he believed it for the best interests of the Society, that the re-election of its presiding officer should not become a mere matter of form. Entertaining these views and having been already twice re-elected, he felt himself not only at liberty but impelled by a sense of duty to decline a re-nomination. In so doing, however, he did not wish to renounce active interest in the Institute. In withdrawing his own name as a candidate, he desired to place in nomination Mr. J. Vaughn Merrick.

The other nominations were then made as follows:

For Vice-Presidents, George Erety, Coleman Sellers and Robert Briggs.

For Resident Secretary, Prof. Henry Morton.

For Treasurer, Frederick Fraley.

For the Board of Managers, George Erety, William J. Horstmann, Henry Cartwright, Samuel Hart, B. H. Moore, H. G. Morris, William B. Bement, E. Y. Townsend, William Sellers, Robert Briggs, Prof. Robert E. Rogers, James Moore, G. S. Rosengarten, J. Harrison, William P. Wilstach, Edward Longstreth, R. A. Tighlman, Barton H. Jenks, Robert H. Long, Alexander Irvine.

For Auditor, J. H. Cresson and Mordecai Haines.

The President then appointed as Judges of Election, William A. Rolin, Henry Aimes, Clarence S. Bement, Mordecai W. Haines, C. Eugene Meyer, Hector Orr and John L. Perkins.

The meeting was then, on motion, adjourned.

HENRY MORTON, Secretary.

Bibliographical Notice.

PHOTOGRAPHIC MOSAICS; An Annual Record of Photographic Progress. Edited by M. C. Lea, M.D., and E. L. Wilson, Editor of *Philadelphia Photographer*.

WE have received from Messrs. Bennerman & Wilson the above work. Its neat binding and clear typography are *prima facie* evidences of its worth. A fuller examination of its contents will add to the conviction that it is a valuable contribution to the photographic art. It is, indeed, a photographer's *vade mecum*, full of valuable receipts and practical suggestions for securing excellence and avoiding defects in photographic work, with wise lessons of economy and judicious advice to landscape and portrait experimenters.

Photography is now becoming so widely popular and so very important an art in many branches of science and industry, that any contributions which help to advance its certainty, economy and scope, are to be hailed with satisfaction. Messrs. Bennerman & Wilson, by the publication of their *Philadelphia Photographer*, have done a great and good work in this direction. Their monthly magazine is in advance of any other publication with which we are acquainted on either side of the water, and, so far as we know, is the only publication in the cause of Photography on this.

We wish, as we anticipate, all success to the new work now before us, *Photographic Mosaics*.

A COMPARISON *of some of the Meteorological Phenomena of* NOVEMBER, 1866, *with those of* NOVEMBER, 1865, *and of the same month for* SIXTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11¼′ W. from Greenwich. By PROF. J. A. KIRKPATRICK, of the Central High School.

	November, 1866.	November, 1865.	November, for 16 years.
Thermometer—Highest—degree	70·00	66·00	80·00
" date	29th.	17th.	1st, '60.
Warmest day—mean	64·50	62·33	72·30
" " date	29th.	17th.	9th, '57.
Lowest—degree	29·00	26·00	16·00
" date	26th.	11th.	25th, '60.
Coldest day—mean	35·83	33·00	23·30
" " date	24th.	11th.	25th, '60.
Mean daily oscillation	13·63	11·63	13·19
" " range	5·85	4·73	5·66
Means at 7 A. M.	42·95	41·43	41·31
" 2 P. M.	52·33	49·63	50·38
" 9 P. M.	46·93	44·45	44·57
" for the month	47·40	45·17	45·42
Barometer—Highest—inches	30·358	30·405	30·661
" date	5th.	10th.	12th, '51.
Greatest mean daily pressure	30·327	30·387	30·520
" " " date	5th.	11th.	12th, '51.
Lowest—inches	29·327	29·395	29·080
" date	16th.	22d.	4th, '64.
Least mean daily pressure	29·382	29·443	29·150
" " " date	16th.	22d.	4th, '64.
Mean daily range	0·157	0·156	0·182
Means at 7 A. M	29·913	29·901	29·909
" 2 P. M	29·858	29·837	29·861
" 9 P. M	29·891	29·877	29·896
" for the month	29·887	29·872	29·889
Force of Vapor—Greatest—inches	0·513	0·534	0·832
" date	29th.	17th.	8th, '57.
Least—inches	·060	·094	·055
" date	25th.	28th.	25th, '57.
Means at 7 A. M	·218	·201	·223
" 2 P. M	·213	·218	·228
" 9 P. M	·242	·217	·232
" for the month	·224	·212	·228
Relative Humidity—Greatest—per cent	89·0	96·0	100·0
" date	11th & 26th.	21st.	Often.
Least—per cent	25·0	33·0	25·0
" date	25th.	13th.	7, '63 & 25, '66
Means at 7 A. M.	74·6	74·6	77·0
" 2 P. M.	51·0	58·7	58·5
" 9 P. M.	71·0	70·2	73·1
" for the month	65·5	67·8	69·5
Clouds—Number of clear days*	10·	12·	8·6
" cloudy days	20·	18·	21·4
Means of sky covered at 7 A. M	56·7 per ct	57·7 per ct	60·3 per ct
" " " 2 P. M	56·7	55·0	60·3
" " " 9 P. M	49·0	39·3	51·9
" " for the month	54·1	50·7	57·5
Rain—Amount—inches	1·474	3·598	3·623
No. of days on which rain fell	7·	6·	10·3
Prevailing Winds—Times in 1000	S 84°17′ W ·251	N 51°46′ W ·255	N 72°53′ W ·257

* Sky one-third or less covered at the hours of observation.

A COMPARISON *of some of the Meteorological Phenomena of the* AUTUMN *of* 1866, *with those of* 1865, *and of the same season for* SIXTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11¼′ W. from Greenwich. By PROF. J. A. KIRKPATRICK, of the Central High School.

	Autumn, 1866.	Autumn, 1865.	Autumn, for 16 years.
Thermometer—Highest—degree	91·00	89·00	95·00
" date	Sept. 3.	Sept. 4 & 6.	Sept. 12, '51.
Warmest day—mean	82·00	82·50	85·20
" " date	Sept. 2.	Sept. 12.	Sept. 6, '54.
Lowest—degree	29·00	26·00	16·00
" date	Nov. 26.	Nov. 11.	Nov. 25, '60.
Coldest day—mean	35·83	33·00	23·30
" " date	Nov. 24.	Nov. 11.	Nov. 25, '60.
Mean daily oscillation	13·83	11·62	14·80
" " range	5·47	4·89	5·26
Means at 7 A. M	53·52	54·90	51·98
" 2 P. M	63·44	62·54	62·62
" 9 P. M	56·87	57·57	55·65
" for the Autumn	57·94	58·34	56·75
Barometer—Highest—inches	30·358	30·405	30·661
" date	Nov. 5.	Nov. 10.	Nov. 12, '51.
Greatest mean daily pressure	30·327	30·387	30·520
" " " date	Nov. 5.	Nov. 11.	Nov. 12, '51.
Lowest—inches	29·327	29·155	29·012
" date	Nov. 16.	Oct. 15.	Oct. 26, '57.
Least mean daily pressure	29·382	29·266	29·059
" " " date	Nov. 16.	Oct. 19.	Oct. 26, '57.
Mean daily range	0·146	0·145	0·149
Means at 7 A. M	29·895	29·876	29·922
" 2 P. M	29·838	29·824	29·879
" 9 P. M	29·877	29·865	29·906
" for the Autumn	29·870	29·855	29·902
Force of Vapor—Greatest—inches	0·864	0·874	0·991
" date	Sept. 2.	Sept. 14.	Sept. 6, '54.
Least—inches	·060	·094	·055
" date	Nov. 25.	Nov. 28.	Nov. 25, '57.
Means at 7 A. M	·358	·366	·339
" 2 P. M	·366	·373	·356
" 9 P. M	·391	·382	·359
" for the Autumn	·371	·374	·351
Relative Humidity—Greatest—per cent	96·0	96·0	100·0
" date	Oct. 13.	Nov. 21.	Often.
Least—per cent	25·0	33·0	23·0
" date	Nov. 25.	Nov. 13.	Oct. 21, '59.
Means at 7 A. M.	78·2	74·2	77·7
" 2 P. M.	55·5	58·0	57·1
" 9 P. M.	75·6	70·4	73·5
" for the Autumn	69·7	67·5	69·4
Clouds—Number of clear days*	28·	31·	29·1
" cloudy days	63·	60·	61·9
Means of sky covered at 7 A. M.	64·2 per ct	60·6 per ct	58·3 per ct
" " " 2 P. M.	54·5	55·8	56·2
" " " 9 P. M.	47·9	36·7	42·9
" " for the Autumn	55·5	51·0	52·5
Rain—Amount—inches	12·469	13·532	10·992
No. of days on which rain fell	26·	22·	27·3
Prevailing Winds—Times in 1000	N 72° 1′ W ·161	N 77° 28′ W ·218	N 77° 52′ W ·222

* Sky one-third or less covered at the hours of observation.

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

Vol. LIII.] FEBRUARY, 1867. [No. 2.

Editorial.

THE U.S.S. ARMORED FRIGATE NEW IRONSIDES.

This vessel, famous in naval history as our first successful sea-going iron-clad steamer, as well as for the service she performed in the great rebellion, was destroyed by fire, in the League Island channel, near this city, on the 16th of December last.

We believe that, outside of official documents, no authentic record exists of her dimensions and peculiar features, nor of the history of her inception and construction. We have therefore obtained, and propose to place before our readers, the prominent and most interesting facts relating to her.

The subject of plating vessels of war had, notwithstanding the building of certain French and English iron-clad vessels, received but little attention in this country prior to the middle of the year 1861. During the first months of the war, the Navy Department was too busily engaged in obtaining a respectable fleet of vessels of offence, to think much of rendering them invulnerable to attack. Nor was it at that time generally realized, how soon the necessity would arise for vessels capable of resisting heavy shot, or how important such powers of resistance might prove to be.

To Admiral Joseph Smith, then (and still) at the head of the Bureau of Yards and Docks, in the Navy Department, we are, as a nation, most indebted for the first outlook in this direction. He had the sagacity to perceive and the ability to urge successfully upon the Department the importance of taking such action as would elicit the ideas of practical ship and machinery builders, in regard to the best mode of combining within one hull, the power of flotation in shallow water, with powers of offence, defence and locomotion by steam.

On the 8th of August, 1861, a commission was appointed by the Honorable Secretary of the Navy, under authority of an act of Congress, approved August 3d, 1861, to investigate plans and specifications, and to obtain proposals for, the construction of armored vessels; to compare these plans, decide on their relative merits and recommend to the Secretary the award of contracts on preferred plans; the aggregate value of which plans should not exceed $1,500,000.

This Commission was, with great propriety, made to consist of Admirals (then Commodores) Joseph Smith and Hiram Paulding, and Admiral (then Commander) C. H. Davis.

In pursuance of their duties, the Commission received proposals for seventeen different plans of vessels.

Of these plans only three were considered feasible as combining the proper qualifications; which had been defined in the following advertisement issued August 7th, 1861:

"IRON-CLAD STEAM VESSELS."

"The Navy Department will receive offers from parties who are able to execute work of this kind, and who are engaged in it, of which they will furnish evidence with their offer, for the construction of one or more iron-clad steam vessels of war, either of iron or of wood and iron combined, for sea or river service, to be not less than ten nor over sixteen feet draught of water, to carry an armament of from eighty to one hundred and twenty tons weight, with provisions and stores for from one hundred and sixty-five to three hundred persons, according to armament, for sixty days, with coal for eight days. The smaller draught of water compatible, with other requisites, will be preferred. The vessel to be rigged with two masts, with wire rope standing rigging, to navigate at sea.

"A general description and drawings of the vessel, armor and machinery, such as the work can be executed from, will be required.

"The offer must state the cost and the time for completing the whole,

exclusive of armament and stores of all kinds, the rate of speed proposed, and must be accompanied by a guarantee for the proper execution of the contract, if awarded.

"Persons who intend to offer are requested to inform the Department of their intention before the 15th August, instant, and to have their proposition presented within twenty-five days from this date."

In accordance with the award of the Commission, contracts were entered into with the three following parties, under guarantee to perform all that they agreed on, viz:

1st. Bushnell & Co., New Haven, Connecticut; price $235,250. Vessel of wood, and of rounded shape, to carry a broadside battery, and to be clad with iron bars of peculiar construction. Draught of water, ten feet; length, one hundred and eighty feet; breadth, thirty-two feet; depth, twelve and two-thirds feet.*

2d. Merrick & Sons, of this city, well known as the builders of the machinery of many of the naval vessels then afloat; price, $780,000. Vessel of wood, with sides sloping inward above water-line, clad with four and a half inch armor in solid plates; to carry a broadside battery. Draught of water, fourteen feet; displacement, three thousand three hundred tons.

This vessel was the *New Ironsides*, a full description of which will be given below.

3d. Captain John Ericsson, of New York; price, $275,000. Vessel of iron, having projecting guards below and above the water-line, deck very low, surmounted by revolving turret for two guns. Plate-laminated armor and turrets. Length, one hundred and seventy-two feet; breadth on deck, forty-one feet; depth, eleven and a half feet; displacement, twelve hundred and fifty-five tons.†

The designers of the *New Ironsides* adopted the thickness and general size of iron plates then used in foreign navies, and formed the sides of the vessel on an angle, as in the French ship *La Gloire*. But they were obliged in other respects, from the very light draught of water to which they were restricted, to strike out a new path; for it should be borne in mind that in many important respects the light draught vessel labors under disadvantage as compared with that of deep draught.

---

* This vessel was the *Galena*. Her armor was found too light for service, although as heavy as could be carried with her light displacement.

† This was the original *Monitor*, the type of all of the armored vessels afterwards built.

1st. Her lines must be more full (other things being equal), and hence more difficult of propulsion and of manageability.

2dly. Her screw must be smaller, and therefore less effective as an instrument of propulsion.

3dly. Her hull must be more strengthened owing to lack of depth, and must, therefore, be heavier to possess the same power of resistance to the action of the sea, and, in the case of armored vessels, to the weight of the armor.

The dimensions adopted were as follows:

HULL.

	Feet.	Inches.
Length over all	249	6
" on load-line	242	2
" between perpendiculars	230	0
Beam, moulded	55	9
" over planking	56	7
" " plating ($4\frac{1}{2}$ inches)	57	4
" " " at spar-deck	46	2
Depth to plank-shear above base-line	26	7
" top of rail " "	29	3
" upper port-sill " "	24	2
Load-line above base-line	14	5
" " " bottom of keel	15	0
Timber frames at throats, moulded	1	6
" " turn of bilge "	1	1
" " vertical sides "	0	9
" " spar-deck "	0	7
Solid from stem to stern.		
Planking on floor	0	5
" increasing to lower edge of plating to	0	$9\frac{1}{2}$
" recessed for lower tier " "	0	$6\frac{1}{2}$
" thence to plank-shear	0	5
Ceiling from turn of bilge to spar-deck	0	8
Water-ways very heavy, especially at lower deck close to load-line.		

ARMOR.

	Feet.	Inches.
Plating begins below load-line	4	0
Width of the lower tier	2	4
Thickness " "	0	3
Above which it was	0	$4\frac{1}{2}$

This plating extended completely round the vessel, from four feet below load-line to three feet above it, terminating forward in a ram four and a half feet deep and nine inches thick, which projected six feet from the stem. Above the upper edge of this plating, which terminated the vertical sides amid-ships, the sides began to "batter" in-

ward, falling back five feet seven inches in a height of ten feet; the plating covered these sides for a length of one hundred and seventy feet and was carried flush with top of plank-shear water-ways. The spar-deck beams were covered with one-inch iron plating and this with four inch plank; all hatches were protected with gratings composed of bars six inches by one inch on edge, held one and a half inches apart by thimbles, and the whole held together by bolts through thimbles and bars.

There were three decks, the lower or berth-deck being cut through for engines and boilers.

The plating was secured by galvanized iron wood screws, having countersunk heads, slotted for a screw-driver wrench; the inner sides of the plating were protected from corrosion by contact with the wood by caoutchouc paint, and a thick caulking of the same was paid into the ledge seam under the lower tier of plating, to protect it from the galvanic action which would have resulted from contact with the copper sheathing.

The plating was grooved on edges, sides and ends, and square tongue-rods of iron, one by one and a half inches, laid in to break the joint.

Heavy timber bulkheads between the berth and gun-deck, and between the gun and spar-decks, extended across the vessel, both forward and aft, the distance between them being one hundred and sixty-three and a half feet, or somewhat less than the length of the outside plating. These bulkheads above the gun-deck were covered with diagonally laid iron bars, two inches thick, in two thicknesses, one overlaying the other. Outside of these bulkheads, on the gun-deck aft, was the captain's quarters, and forward was the sick bay.

In each bulkhead was a door of five-inch solid plate, sliding on rollers movable by rack and pinion.

These bulkheads enclosed the gun-deck, and proved an effectual barrier to raking fire.

MACHINERY.

The motive machinery consisted of four horizontal fire-tube boilers of seventeen feet front, and six furnaces each, giving a collective grate area of three hundred and fifty-six square feet, and of heating surface eight thousand seven hundred and seventy-six square feet. Coal was carried in hanging bunkers over the boilers as well as below the berth-deck.

The engines were two horizontal direct-acting, of fifty-inch cylinders,

thirty inches stroke, having surface condenser, and driving a four-bladed screw thirteen feet diameter, twenty feet pitch. Small as it was for a ship of three thousand five hundred tons displacement, it was as large as could be got in, owing to the massive projecting counter, the lower edge of which was two feet under water, and which carried the weight of the stern plating. At a speed of sixty revolutions (which could readily be maintained) the ship could be driven at eight and a half knots (nautical miles) per hour in still water.

The coal carried was three hundred tons, which would last for nine days full steaming.

BATTERY.

The ship was originally designed to carry a battery of sixteen nine-inch Dahlgren guns, and a crew of one hundred and sixty-five men to work it. But after launching, it was found that there was such a superabundance of buoyancy provided in the hull, as to permit the battery to be increased to fourteen eleven-inch Dahlgren guns and two two hundred-pounder Parrott rifle guns, with crew for the same of four hundred and fifty men, without making the load-draught greater than had been stipulated.

This fortunate circumstance, resulting from an excessive caution on the part of the builders, proved to be of the first importance in the subsequent history of the ship, increasing very greatly her offensive powers, although at the same time it prevented the attainment of the stipulated rate of speed, the calculation for which had been based on a reduced displacement.

The additional weight carried over that provided for in the contract was five hundred and fifty tons.

The load-draught, with full coal and stores, was, in salt water, fifteen feet above bottom of keel.

The weights carried were as follows:

	Pounds.
Weight of deck armor	350,000
" " side armor and port-shutters	1,450,000
Total weight of armor	1,800,000
Weight of machinery	730,000
" " water in boilers	150,000
Total weight of machinery	880,000
Weight of ordnance, carriages and ordnance stores	898,000
" " provisions, clothing and small stores	233,000
Total weight ordnance and stores	1,131,000

Such is a concise description of the *New Ironsides.* She was contracted for October 15th, 1861, launched May 15th, 1862, and sent to sea complete August 21st, 1862, in ten months after date of contract. It is believed that there are few if any instances on record of a work of such magnitude—good work, too, not slighted in any respect—being done in so short a period. Especially is this despatch remarkable, when we consider the fact that the vessel was an experiment, involving many novelties of construction; that a tremendous pecuniary responsibility rested upon her builders, who had designed the ship, and had guaranteed certain results; and that the eyes of the nation were turned towards her, anxiously awaiting her success. The consciousness of these circumstances, and a knowledge of the great service she might render in subduing the rebellion, would naturally render her builders more cautious in their advance.

We learn from Messrs. Merrick & Sons, her designers and builders, (to whom we are indebted for most of the particulars herein stated,) that the credit of originating the *New Ironsides* is due to their late superintendent, B. H. Bartol, Esq., who also planned the armoring and supervised its fitting on board, and to whom the general supervision of the hull was confided. The wood-work of the hull was built under subcontract with them by Messrs. William Cramp & Sons, of this city.

The armor plating was hammered of the best Pennsylvania charcoal scrap iron, half of it by Bailey, Brown & Co., of Pittsburgh, Pa., and half by the Bristol Forge Co., Bristol, Pa.

The *New Ironsides* proved herself an admirable sea-going vessel, and was, of all the iron-clad vessels in our navy, the especial favorite of officers and men, for her thorough ventilation, her safety in heavy weather and the formidable character of her battery. It is, we think, a subject of great regret to all, that by her destruction our navy has suffered so severe a loss, and especially that the Navy Department has not developed to some extent the ideas presented in her construction by building other similar vessels, improved, as they doubtless would have been, by experience with her. Without entering into a discussion of the question of the relative merits of broadside and of turret battery, it is at least beyond dispute, that for rapid and continuous firing, such as would be required in the reduction of large forts, the broadside battery presents advantages hitherto unattainable by the use of revolving turrets.

Some difficulty was at first experienced in steering, owing to the immense mass of the hull and her very full water-lines, which required

quick meeting with the helm to prevent the vessel taking a sheer. Until the pilot and the men employed in steering became accustomed to this peculiarity, her speed was limited by it. A little experience, however, enabled them to control perfectly the direction given, and her reputation for manageability became established.

Unfortunately, during the harbor attack upon Charleston, April 7th, 1863, the steering of the ship was taken out of the hands of her own pilot; and the ship being in a swift tide-way and very shoal water (eighteen inches more than her draught), some difficulty was experienced in her steering. This having been improperly attributed to the vessel, injured her reputation until the facts became known.

We conclude this account by giving a copy of the record of the firing done by the *New Ironsides* in service at Charleston Harbor. Her armor bore evidence of the severity of the attacks to which it was subjected. Not only was it never perforated, but the deepest indentation was not over half its thickness.

RECORD OF FIRING, &C.

April 6th, 1863.	Crossed the bar—Charleston Harbor.
" 7th, "	Got underweigh 12½ P. M. Came out at 5 P. M. Struck several times and lost a port-shutter. Fired eight shots.
July 18th, "	Commenced 12·15 P. M. Ceased 7·49. Struck ten times. Fired eight hundred and five rounds.
" 20th, "	Commenced 2·8 P. M. Ceased 4·27. Struck thirteen times. Fired one hundred and sixty-eight rounds.
" 24th, "	Opened 5·43. Ceased 9·55. Struck twelve times. Fired two hundred and twenty rounds.
" 29th, "	Opened 12·20 P. M. Ceased 2·45. Struck two times. Fired two hundred and ten rounds.
" 30th, "	Opened 11·32 A. M. Ceased 1·45. Struck three times. Fired three hundred and sixty-six rounds.
Aug. 17th, "	Opened 7 A. M. Ceased 1 P. M. Struck thirty times. Fired four hundred and twenty-eight rounds.
" 18th, "	Opened 8·15. Ceased 9·45. Not struck. Fired one hundred and eighteen rounds.
" 19th, "	Opened 1·50. Ceased 2·25. Not struck. Fired sixty-four rounds.
" 20th, "	Opened 11·20 A. M. with spar-deck rifle, firing twice. 1·20 opened on Fort Wagner. Ceased 3·30 Fired one hundred and fifty-eight rounds.
" 21st, "	Opened 6 P. M. Ceased 7·30. Struck by 11-inch shot in port-bow. Fired one hundred and fourteen rounds.
" 22d, "	Opened 11·40. Ceased 1·45. Fired one hundred and eighty-two rounds.
" 23d, "	Opened 8 A. M. Ceased 9. Struck five times. Fired eighty-eight rounds.

Sept. 2d, 1863. Opened 1·50 A. M. Ceased 4·30. Struck seven times. Fired fifty rounds.
" 5th, " Opened 9·45 A. M. Ceased 6·35 P. M. Struck fifteen times. Fired five hundred and four rounds.
" 6th, " Opened 5·15 A. M. Ceased 6·30 P. M. Struck three times. Fired two hundred and thirty-eight rounds.
" 7th, " Opened 5·45 P. M. Ceased 7·15 P. M. Struck fifty times. Fired one hundred and fifty-two rounds.
Oct. 5th, " Torpedo exploded under starboard side, 9 P.M., mortally wounding by the concussion Acting Master Howard, who died October 10th. But beyond driving a deck-beam on end to shattering a knee, doing no material damage to the ship.

RECAPITULATION.

Total time in action ....68 hours 49 minutes.
" number of rounds ....4361.
" " times hit ....250.

From the date of her first going into commission, previous to her departure for Fortress Monroe, in August, 1862, and during the earlier part of the siege of Charleston, she was commanded by Com. Thomas Turner. He was relieved by Capt. S. C. Rowan, who remained in command until her return to Philadelphia, in June, 1864. August 1st, 1864, she was placed in charge of Com. Radford, and left Philadelphia September 25th, 1864, for Hampton Roads; in the vicinity of which, making occasional trips in the James River, she remained till December 13th, when she took her departure on the Fort Fisher expedition. January 13th, 14th and 15th, 1865, she was engaged in the famous attack on that fortress. On the 20th instant she returned to Hampton Roads. On March 30th she arrived at the Navy Yard, Philadelphia, and went out of commission for the last time, April 6th, 1865.

PARIS EXPOSITION.

As the time approaches for the opening of the great International Exposition at Paris, some anxiety must be felt by Americans, proud of the resources of their country, as to the extent of its representation as a nation. That it will be fully represented is in no way possible. Its mineral wealth will be shown, and much that is interesting in connection with the art of war, both in its instruments of destruction, and its appliances for saving life, as well as many interesting records of what

has been so wonderfully developed during the late war in respect to the quartermaster department in a sanitary point of view. Any amount of models of crude invention will find their way there; but to what extent the mechanical talent of the country will be shown by machines now celebrated in this country, and we may say peculiar to the country, remains to be seen. Philadelphia has been noted for some years for the superior class of machinist-tools. We hear that a leading firm in this branch of manufacture will send many valuable representatives of their work. It may also be noted that an important French invention, viz: the Giffard Injector, for supplying steam-boilers with water, has been, in this city, so improved by the American makers, as to go back to its place of origin almost a new instrument, simplified and rendered much more efficient. Some time during this year we will be able to present our readers with some interesting data in connection with the American improvements on this instrument. From some of the members of the Institute, who will be in Paris during the exhibition, we hope to receive many interesting facts, and should be glad to hear from those cognizant of such matters as much as possible about what is being done on this side of the water in the way of preparation. . . .

ENGINEERING ITEMS.

Railways in India.—From the report by the Government Director of the India Railway Companies, just published, we learn that the increase of lines during the year 1866, is about three hundred and eighty-seven miles, making at present the total length of tracks in that country three thousand three hundred and thirty-two miles. During this year the iron girder-bridge over the Jumna has been finished, thus completing the line from Calcutta to Delhi, a distance of one thousand and twenty miles, which may thus be now traversed in thirty-seven hours. As would be expected, only two hundred and fifty miles have been laid with double track.

A line is now under contract from Burdwau to Luckeserai at £8500 per mile, exclusive of permanent way and rolling stock, which items will probably bring up the cost to £14,000 per mile, or £2,000,000 for the whole one hundred and forty-five miles. The entire rolling stock of the Indian railways is represented by seven hundred and thirty-three locomotives, sixteen hundred cars and sixteen thousand trucks,

while four hundred and eighteen more engines are ordered, though their delivery is to be distributed over many years. The total outlay for these roads is £60,860,000, which pays an average interest of three and a half per cent.

Railway from Vera Cruz to Mexico.—An enterprise of unusual difficulty, and without a parallel in some points, is contemplated under the above title. The elevation to be reached at the summit is eight thousand four hundred feet, and this actual height must be climbed from the ocean-level in a distance of one hundred and fifty miles. The gradient is for great distances as much as one in twenty-five, and this with many and short curves. Comparing the actual elevation reached with the highest already constructed, we find that this greatly surpasses, while in no other case is the whole hill climbed, as in this case, from the very foot or ocean-level. Thus, the highest in Great Britain—the Caledonian—reaches to but one-fifth of this elevation. The Baltimore and Ohio Railroad mounts to two thousand six hundred and twenty-six feet; the summit of the Semmering incline is two thousand eight hundred and eighty-seven feet, and the intended summit of the Mount Cenis Railroad is five thousand eight hundred and fifteen feet. The engineer of this work is Mr. Samuel.

The bridge over the Niagara River at Buffalo, according to the designs of Mr. T. W. Kennard, will be constructed in spans of two hundred and fifty feet, supported on piers constructed with iron cylinders filled in with ashlar masonry, and surrounded by cribs loaded with broken stone. The total weight of each pier will be five thousand three hundred and seventeen tons. The superstructure will consist of wrought iron trussed girders, and it will carry a railway and road, side by side.

The railway bridge across the Schuylkill at Girard Avenue, for the Connecting, or Belt, Railroad is now almost finished, and presents a very imposing appearance. Its solid approaching arches, seemingly of about fifty feet span and eighty feet height, and its iron centre spans towering far above the adjacent Girard Avenue road-bridge, itself a lofty structure, are quite impressive. We lately noticed unusual activity in the operations upon the iron part of this bridge, which was explained by a glance below. The ice had formed solidly across the river, embracing, of course, the trestle-work on which the unfinished structure rested, and had this moved, as there is always risk of its doing in our uncertain climate, trestle-work and spans must have gone with it. All is, however, by this time safe.

Massive embankments are to be constructed on the Loire, the Cher and the Garonne, to protect the surrounding districts from those violent floods which have so often desolated them. The city of Tours is to be protected in some places by masses of masonry one hundred yards in breadth, as we learn from the *London Mechanics' Magazine*, page 280.

Petroleum fuel.—We read very favorable accounts of the improvement lately made by Mr. C. J. Richardson in connection with this subject, which seems chiefly to consist in the introduction of steam among the ignited fluids, by means of which it is stated the heavier oils may be burned, and these, burning, caused to yield a much larger equivalent of heat than can be obtained from the more volatile products. The convenience of a liquid fuel, in many respects, is very manifest, and if it can be brought within the requisite economic limits, its applications would be numerous and important.

A tunnel under the English channel.—We learn that surveys with reference to such a structure, have been actually undertaken under the management of Messrs. Brunel and Hawkshaw.

A tunnel through the Sierra Nevada.—A company has been formed in California for the purpose of carrying the water of Lake Tahoe to San Francisco by means of a tunnel, which will traverse part of this great range.

Experiments with Nitro-glycerine, (or, as it may be more briefly called, nitroleum,) made by M. Kopp, show that fifteen grammes (about four pounds) of this substance will detach about seventy cubic metres (= two hundred and fifty cubic yards, or four hundred tons) of hard rock.

The raising of a sunken steamship by the application of centrifugal pumps, was lately accomplished with great success by Messrs. Gaurlay Brothers, of Dundee.

The vessel raised was the steamer *London*, which sank in the river Tay, in consequence of a collision with the screw-steamer *Harvest Home*.

The leaks in the injured vessel having been repaired as far as practicable by divers, the last and successful trial with pumps was made on the 24th of December. Five centrifugal pumps of Gwynne's pattern were used. Two of the largest, having twelve-inch suction pipes, were placed on a steamer, (the *Queen*,) and arranged so as to be driven independently from her screw-shaft. Another pump, with nine-inch suction-pipe, was placed in a lighter, and driven by a separate engine.

Two other pumps were arranged on the deck of the *London*, with a donkey-engine to work them, which was supplied with steam from the boilers of the *Queen*.

With these appliances the vessel's deck was dry in twenty minutes after starting the pumps, and she was soon after afloat and towed off.

The ventilation of millstones.—A very important case has been lately decided in the English patent courts with regard to the above subject, the verdict being against the claimant or patentee, and securing to the public, right to use the process, which seems to be of great value, enabling more than three times the quantity to be ground, which could be otherwise worked in the same time.

The process consists simply of an application of fans, to induce currents of air through the stones in company with the grain and flour, and of porous material to separate the flour from the escaping air.

Non-explosive gunpowder.—By this title is designated a preparation invented by Herr G. A. Neumeyer, of Leipzig, which will only *explode* when closely confined, but when exposed to the air simply *burns*.

The process, as described in the English patent taken out in the name of Dr. August Klein, is the same as that for ordinary powder, except, that the "glazing" is omitted, (by which the tendency to absorb moisture is said to be decreased,) and in the proportion of the ingredients, which, compared with that of English and American powder, is shown below:

	English and American.	Neumeyer's.
Saltpetre	75·00	75·00
Sulphur	10·07	Flowers of S....6·25
Charcoal	15·00	18·75

Experiments made in Germany and France with this powder, in the Prussian needle-gun and French infantry guns, show its projectile force to surpass somewhat that of ordinary powder; while its immunity from explosion, when not inclosed, was conclusively shown in certain experiments conducted on the cricket-ground of the Sydenham Crystal Palace, where, among other things, two kegs containing together thirty-five pounds of this powder, were ignited in a small building, and each keg having a hole five inches in diameter in the top, the powder burned away without any explosion.—(See *Engineering*, December 21.)

Novelties
IN CHEMISTRY AND PHYSICS.

A new process for the economical manufacture of sulphide of ammonium on the large scale, is published by Peter Spence in a paper read before the Manchester Literary and Philosophical Society. It consists in mixing a salt of ammonia, say sulphate or chloride, with double its weight of soda waste or gas lime, blowing into the mixture a jet of steam, and condensing the escaping gas.

The condensers must, however, be watched, as the sulphide of ammonium will at first come over so strong as to condense in a solid form. The physiological effect of this gas when present in quantity is curious. Thus, a sudden escape caused a man standing near to lose consciousness, and to become perfectly rigid in a few moments. Violent rubbing of the chest, and cold water on the head, redeveloped vitality, with violent convulsions, lasting one and a half hours, but no ill-effects were experienced the next day. This poison is sudden and violent, but if not at once fatal, seems very transitory in its effect.

Disinfectants and deodorizers.—The Lords of the Admiralty have ordered that the use of Burnett's disinfecting fluid (chloride of zinc) shall be discontinued in the Royal Navy, in consequence of several fatal cases of poisoning which have occurred from its accidental mixture with food. It has, moreover, been discovered that this fluid is not a disinfectant, but only a deodorizer. Carbolic acid is to be substituted.—*Chemical News.*

Artificial tannin may be prepared by treating lignite (wood fibre) with nitric acid, according to a process developed by Mr. Wm. Skey, and mentioned in the *London Mechanics' Magazine*, page 294. The same gentleman finds that freshly burned charcoal will remove nitric acid from a dilute mixture containing both this and sulphuric acid.

Silver may be substituted for platinum in a Grove's battery, as appears from some experiments lately announced to the French Academy, provided one-quarter part of hydrochloric acid be added to the nitric. A film of insoluble chloride in this case protects the plate. The fumes of chlorine which must undoubtedly be added to those of nitrous acid, would, however, prove, we think, a serious objection to the use of this plan.

Instantaneous photographs by artificial light, we see an-

nounced by some of our contemporaries, and on looking the subject up we find that the idea, originates with a plan devised by a Mr. T. Skaife, and for which he has secured provisional protection. The apparatus and manipulation are fully described in the *British Journal of Photography*. We do not, however, perceive from the account given, how sufficient power is obtained to render an instantaneous illumination effective in producing a picture. Burned in the ordinary way, it takes many grains of magnesium, burning for some fifteen seconds, to produce the effect, and we do not understand how a "few grains" burned in a flash, can accomplish as much.

Spontaneous ignition of colored fires.—From some experiments made by Chas. Bullock, Esq., of this city, it appears that the use of flowers of sulphur in these mixtures is a fruitful cause of such action. By preparing a material without this ingredient, which may be very successfully accomplished in most cases, it will keep well for years.

Philosophical toys.—We have just received from Messrs. Queen & Co. a number of articles which may well come under the above title, and which have many points of interest in a scientific direction. They may be described as follows:

Japanese matches.—These are little allumettes of soft paper, having about the thickness of straws, and being about three inches long. They are to be ignited at one end, and burning for a few moments, accumulate a little ball of melted matter from which are emitted a series of the most beautiful flower-like sparks. The preparation of these articles is fully described in the *London Chemical News*, December 24th, 1864, and January 27th, 1865, and consists in grinding together two parts of sulphur, 1·5 parts of lamp-black and four parts of nitre, care being required to give the exact amount of comminution necessary.

Chinese straws.—These have the exact appearance of such fragments as break off from a whisp-broom, but when thrown on a vessel of warm or even cold water, expand into sprays of flowers, birds, figures and other objects.

Mr. Coleman Sellers some months since examined these curious things, and with his usual sagacity soon discovered the method of their manufacture, and produced a number of them himself. A block or bar of pith is taken and carved into a profile likeness of the object to be represented, so that a cross-section made anywhere in its length will show the same figure. (The sticks of candy containing names will illustrate what we mean.) The surface is then colored and the whole

block is compressed from the sides, in a vice, until reduced to a thin plate. This is then cut with a knife into thin slices or straws. Each of these when expanded by imbibing water shows the original profile or cross-section of the block.

There are many more of these toys among the collection above mentioned, but our limits oblige us to defer further description to our next number.

Crystallized cards.—From Mr. James T. Shinn we have received specimens of cards, covered with a beautiful silky crystallization, which is under the enamel and does not prevent successful writing or printing on the surface.

The plan was first suggested by a French article of the same kind made with acetate of lead, which was very objectionable on account of its smell and poisonous properties. The salts here used are, however, inodorous and innoxuous, and the effect produced is very beautiful. The principle on which these preparations are based have been very fully discussed in a series of papers on the crystallogenic force, published in the *Comptes Rendus* for 1864, by M. F. Kuhlmann. The experiments leading to this improvement were conducted by Mr. Robert Fairthorne, in conjunction with Mr. Shinn, and the cards are now manufactured by Mr. Collins.

Paper which turns pale ink at once black, called by its inventor, Mr. J. E. Hover, carbonized paper, has been submitted to our examination and experiment. The action claimed is undoubtedly effected, and this without any detriment to the character or durability of the paper, since the means employed is the introduction into the glazing of a neutral carbonate, which, while effecting a prompt oxidation of the ink, has none but a beneficial action on the fibre of the paper

---

To Our Readers.

The change of management and other alterations in this *Journal* have caused some delay in the issue of the January number, and in the pressure required to make up lost ground in the present issue, many articles of interest have been crowded out. It is thus that some continuations, such as that of Mr. Coleman Sellers' paper on Journal Bearings, the entire Educational Department &c., have been omitted through delay of engravings and the like. These things are not, however, lost, and will be brought out with the more completeness for the delay.

Civil and Mechanical Engineering.

THE STEAM BOILER.

By Joseph Harrison, Jr., Philadelphia.

Of all the elements that have been pressed into man's service, to increase his comforts and conveniences, water turned into steam holds a most important place. And strange as it may appear to the uninformed, it might almost be said, that the steam-engine as matured by James Watt, came from his hands nearly perfect in principle, and, like Minerva from the brain of Jupiter, fully armed and ready to do battle in the varied fields in which it has since been employed. James Watt knew all, and acted with a knowledge of all, or nearly all, the principles that are now known. The main improvements in the steam-engine of our time, consist in a better and simpler arrangement and proportions of parts, better material, better workmanship, and vastly increased size. Many of its better qualities are the result of improved means of manufacture in the use of the steam-hammer,—the planing machine, slotting machine, etc., etc., which with equally improved quality of material, has enabled the steam-engine builder to do such work, as could not have been done under a less improved system, and for which Watt might have sighed in vain.

Not so the steam-boiler. It, from the very first application of steam as a useful agent, has been the constant trouble of the engine-builder, and the engine user, the great source of anxiety, danger and expense. The first patent regularly issued in England for a steam-boiler, dates about a century back, and from that time to this, patents for new designs or improvements, numbering thousands, have been issued in England,—on the continent of Europe, and in this country. Notwithstanding the vast amount of labor and thought that has been bestowed upon the subject, the whole engineering profession still is in doubt as to which is the best steam-boiler, no single one, at this moment, proving so much better than the legion that surrounds it, as to take any very prominent place in the general estimation, and not one combining the most important principle of security against destructive explosion. We might, perhaps, except the locomotive boiler; but even this occupies

its apparently permanent place, more because it adapts itself to the machine in form, than from any inherent value possessed by it as a safe or economical steam generator. Stone, wood, cast and wrought iron, copper, steel and various alloys of other metals, have been tortured, bent and twisted, from the beginning, into almost every conceivable form to make a steam-boiler. Still the work of change goes on, patent upon patent being continually issued for attempted improvements in this much needed object. In the various phases in material and form through which the steam-boiler has passed, it is remarkable that changes have tended more towards saving weight, cost or fuel, than in the more important object of making it safe from explosion. It can hardly be controverted that the paramount aim in the use of steam should be safety, and yet, with all that has been done, no single boiler now in general use, *approaches* this essential requisite in its construction, compared with what is demanded of it. Hence the frightful loss of life—the dreadful maiming and suffering that we find recorded almost daily in our newspapers, and the immense amount of valuable property annually destroyed by steam-boiler explosions. It may be said that there is no remedy for this state of things,—that all has been done and is being done, that skill and ingenuity can devise, to stop such fearful results, but as yet without success. If we *have* arrived at the end, and found no remedy, then must we accept the situation, trusting rather to Providence, care or chance, to protect us from harm, than to any inherent controlling principle in the thing used, voting steam a good servant but a very bad master.

Before concluding this paper, I will endeavor to show that all has not been done in the general use of steam to render it as safe an agent as its wide-spread utility and necessity demand. Nay, more, it will be shown from many years of practical experience in the use of a steam-boiler of singularly original design, and of material not heretofore considered best for the purpose, that the employment of steam at any practicably useful pressure, *can* be made entirely safe from any explosion destructive to life or property.

Some give to Dr. Alban, of Plau, in Mecklenburg, the credit of first enunciating the grand idea that "*all boilers should be so constructed that their explosions may not be dangerous;*" but it is scarcely possible that Evans, Hancock, Gurney and others at a much earlier date, should not have as fully appreciated this most important principle. When the low pressure of the earlier era of the steam-engine was used, the form or material of the steam-boiler mattered little, and we find Savery

using cast iron, Newcomen wrought iron, but from the difficulty of getting good plates of the latter material, Watt even recommended that boilers should be made of *wood*, hooped in the manner of the soap boilers' kettle, with cast iron curb or furnace at the bottom. But when the first really high pressure engine was introduced by our own countryman, Oliver Evans, carrying steam as high as *one hundred pounds to the square inch*, and upwards, it then became necessary to look for material and form capable of sustaining such pressure. Oliver Evans used wrought iron plates in plain cylinders of any given length, and of small diameters, sometimes, with internal return flue, through which the heated products of combustion passed, after coursing the whole length of the lower half of the boiler. These two kinds of boiler are at this day more extensively used in the United States than any other, and may be found almost exclusively on our Western river steamers. Perhaps no other boiler now in such general use, has greater safety in its principle of construction, than this early introduction of Oliver Evans. It is true that the most disastrous explosions on record have occurred with cylinder boilers on our Western rivers, but these calamities have been the result of scanty proportions in the first place, in order to save cost and weight, or from depreciation after long use, rather than from any original defect in principle. If the grand idea insisted upon by Dr. Alban be the true one, then have our engine-builders wandered far away from it since the days of Oliver Evans. Look at the immense structures built up of wrought iron, now so largely made and used on ocean and river steamers! Is this principle of safety attained, or even aimed at, in these boilers? Are they so made that "*explosions are not dangerous?*" Witness the disaster on board the North River steamer *St. John*, in 1865. Here a boiler exploded, made on an approved and often used plan, which, according to the testimony of experts on the Coroner's jury, "*pulsated*" at every stroke of the engine. Has any one seriously considered what this "*pulsating*" means? If anything, it means a movement in certain parts of the boiler, which being kept up for a given, and almost calculable length of time, must inevitably destroy the structure of the material of which these parts are made, and which, like the *wire*, bent backwards and forwards continuously, will eventually break. It is but too true, and not very assuring to the traveling public, that all of the best ocean steamers, as well as those on our rivers, lakes and sounds, have at this moment, boilers theoretically, if not actually, as unsafe as the one that blew up in the *St. John*. It is not too much to say, that all boilers of large di-

mensions, whether of square form, dependent upon stays or braces for their strength, or cylinders of large diameter, with or without internal flues, cannot be safe. Neither is it too much to say, that no boiler is safe, whatever its form or material, that can, under any circumstances, rend and scatter large masses of material, liberating at the same time large volumes of highly charged water and steam.

Take a boiler, if you please, that depends entirely for its strength upon being properly stayed, and there are thousands of such in use, especially for marine purposes. In the nature of boiler work, it is not possible to make such a boiler safe. Let any one, with a full knowledge of how it should be done, watch the making of such a boiler. The drawings are perfect, every strain calculated to a decimal, every proportion exact. If it were possible to execute the work just as laid down, all might be well: but if such a thing is possible, we never have seen boiler work made with such accuracy. In the matter of the stays, (a most important point,) every hole should be exactly smooth and true, and made to come in true line with the one it has to meet. Every bolt should be turned and fitted to its appropriate hole. But all who are acquainted with boiler work, know that it is not even attempted to do it in this manner. Ill-shaped stays, badly made and badly fitted, or strained into ill-shaped places, often out of reach of the eye and hand of the workmen, rough holes most frequently made in the smith's shop, with as roughly made bolts. If the holes are bored, so rudely do they adjust themselves to one another, that the ever ready drift, that bane of safe and good boiler work, brings the parts together under a tension that puts to flight all decimal calculations, and but too frequently dismembers the parts themselves. Can such a boiler be safe? And again, take plate riveting. An English writer on the subject says: "It is a truism, 'that the strength of any structure is its weakest point; but who can say where the weakest point of a steam-boiler is, as ordinarily made?'" "Take a simple cylinder boiler, for instance, the sheets are run through the rolls and bent to the proper radius, and when the riveting gang get to work they close up the rivets with great rapidity, but when the holes come out of line with each other the drift pin is resorted to, and the sheets are literally stretched until the rivets can be inserted; when the drift pin is knocked out, the sheet goes back to its place, and there is already, without a pound of steam pressure, strain enough to cut the rivets off." "Repeat this performance through twenty or thirty feet, the length of an ordinary cylinder boiler, and who can say where the weakest point of the structure is? Suppose such a

boiler made of silk or any flexible material, what shape would it be in?" "It would be full of puckers, folds, seams and gathers, and represent most accurately the various trials to which that most abused of all modern engineering apparatus—the boiler—is exposed." "The case is aggravated, not benefited, when we construct a square boiler, for this shape seems, by general consent, to have been adopted for marine service." "When the angles or flanges of the sheets are not broken by the flange turners, they are cracked out by the drift pin of the riveting gang, and it ought to be made a capital offence to have such a tool (drift) on the premises of any boiler works." "New boilers burst under the most mysterious circumstances; old boilers are patched and then burst; and we are told that 'putting new cloth into old garments is the solution of the trouble.'" "On each occasion the Coroner examines a host of 'experts,' who proceed to declare that the 'iron was burnt,'—'the water low,'—'the stays insufficient,'—'the water changed into explosive gases,' etc.; but it never occurs to these worthies, that the actual strength of the boiler was, in many cases, unknown, and that it may have been at the bursting point for many days, weeks or months, until at length it gave way." "It is ridiculous to suppose that safety is secured by neat-looking rivet-heads or handsomely caulked seams." "Holes will come out of truth with the utmost care, especially in such hap-hazard work as punching is usually made." "Neither are the braces (stays) properly set, for some draw all one way, while others do not draw or hold at all, and are perfectly loose; thus a portion do all the work, and the rest are idle; they impart no strength, and are an element of weakness; for the engineer relies upon them when they are doing no good." "We are confident that a great deal of attention can profitably be given to the mere workmanship of steam-boilers; they are not tanks for boiling water, but great magazines wherein tremendous power is stored, the safe custody of which is of paramount importance to all in the vicinity."

Assuming that a boiler of large dimensions, whether cylinder or marine, *can* be made so that all the parts are joined together without strain, this state of things can only exist at the uniform temperature throughout, under which the boiler has been made. Put fires at white heat, into or under such a boiler, heating the plates in the immediate vicinity of the fire, as must occur, in a much greater degree than at the external or more remote parts of the structure. Surely then the parts that had previously lain quietly together, assume a new and constantly changing condition, and who can tell what these changes are,

their frequency, or to what extent the strength of the boiler is impaired thereby?

Let us now turn our attention to another equally, or perhaps more, important point, than those we have been considering,—the wear and tear of plate-iron boilers. A writer in the *London Mechanics' Magazine* says: "It is not too much to say, that nine out of ten explosions are directly the result of corrosion." "Setting aside the value of human life and limb, we find that the mere pecuniary interests involved in either the gradual or sudden destruction of a boiler are very considerable." "Repairs are, at all times, expensive, and the time lost in making them is often a serious source of pecuniary loss, worry and trouble." "Hence the replacement of a plate, or the alteration in a defective flue, is often staved off from day to day until irreparable mischief is done." "Reflecting upon these things, it seems strange that boilers are made, fired and worked with a negligence, which apparently regards iron plates as indestructible, and the results of an explosion trifling to a degree." "We cannot set such a system,—or rather such a want of system,—down wholly to stupidity or neglect." "We know that boilers in the best hands, and under the most careful management, often become worthless with a startling rapidity, which no amount of theoretical reasoning can account for, nor practical skill arrest or delay." "The utter uncertainty in which the engineer is doomed to live, as to what does or does not promote durability, leads naturally to recklessness, neither the result of want of thought or indolence." "Corrosion is too often regarded in the light of a fate—a destroyer, merciless and indiscriminate, before which as a *fetish*, the manufacturer and ship-owner bow down and submit."

Mr. Colburn, in a paper read before the British Association, in 1864, says: "As a boiler malady, corrosion corresponds in its comparative frequency and fatality to the great destroyer of human life, consumption. It is the one great disease." "A trickling of condensed steam down the outside of a boiler will inevitably produce corrosion, and to this, was directly traced a large number of the forty-seven boiler explosions which occurred in the United Kingdom in 1863, and which caused the loss of seventy-six lives, with injuries more or less serious, to eighty persons."

In the report of the Manchester and Midland Boiler Association, for 1863, we find the following: "Furrowing along a seam of rivets, or rather under the line of an overlap, is found to be the usual malady, but the iron is eaten away almost everywhere; not uniformly over the

whole surface, but in numberless holes." "So far as furrowing is concerned, there can be no doubt that wrought iron is the *worst* material that can be employed for a steam-boiler."

Thus much on the subject of corrosion. Says another article in the *London Mechanics' Magazine:* "Until a comparatively recent date the belief obtained with most engineers, that a riveted joint, if the work were properly done, was superior to the plate itself."

Mr. Wm. Fairbairn, in a series of carefully conducted experiments, upset this fallacy by proving that, "the strength of the plate being taken as one hundred, that of a double riveted joint will be seventy, and a single riveted joint fifty-six;" and this with first rate workmanship. "Fifty-six per cent. of the whole strength of boiler plates, is certainly not much to realize with the best workmanship, but as many boilers are put together, this per centage must be regarded as too high." "There are difficulties involved in the nature of the process, which the best mechanic can only combat,—seldom or never overcome." "However accurately two plates may correspond before being punched, that process inevitably distorts them, and occasions a bad fit when subsequently put together." "The hammering and bending at the edges is invariably injurious to cold plates." "Again, the best workmen, with the best machinery, find it out of the question to make all the holes in a long seam correspond." "The constant use of the drift is certain to follow, and when plates are of inferior quality or very thin, cracks are frequently established from one hole to the other." "The judicious use of the caulking chisel easily conceals the defect, which is none the less serious because it is invisible." "The best rivets too seldom completely fill the holes they occupy." "They are never truly at right angles to the plates, and are often exposed to enormous strain in drawing plates together when they are badly fitted." "We have seen, from this cause, the heads fly off half a score of '*Best, Best*,' rivets at once, in rolling a new boiler from one side of the shed to the other."

Blistering of plates is another trouble in the use of plate iron. Says, —*Engineering Facts and Figures*, for 1863, page 21, "The fact of plates by good makers being liable to blister unawares, and which previous examination fails to detect, shows the importance of not hazarding an expression upon their soundness. Thus the strength of no unassisted plate, exposed to the action of the fire, should be relied on, and consequently it becomes most desirable that furnaces should be in every instance stayed either with flanged seams, or with hoops of angle iron, T-iron or other advantageous form." Thus, at every turn, the

boiler-maker, in using wrought iron, either in plates, rivets or stays, meets with difficulties which can only be partially, never perfectly, overcome. These difficulties occur most frequently at the very points in the structure where danger from defective work or material is most imminent, and where it is least easy to avoid it.

The maintenance of a well made steam-engine is of slight import, nor does the engine proper give the user any great anxiety or trouble as a source of danger to life or property. So true is this, that engines are doing good service now in England, that were made by Watt and his contemporaries; the sun and planet-wheel even yet making their regular revolutions. Where are the boilers that started with these engines? Gone, gone, and many succeeding the first, gone also.

The elements that destroy a steam-boiler commence their work from the moment of its completion, and from the hour it is first filled with water and fired; whether much used or not, the slow, steady, insiduous process goes on, and it is fortunate if its life reaches a decade, ere it is thrown out as worthless, scarce selling in this country for one cent per pound, even after its full original cost has been expended in almost continuous repairs from the beginning. From *Engineering Facts and Figures*, for 1865, we quote the following: "The saying of that distinguished authority in matters mechanical,—Wm. Fairbairn,—'that danger in the use of high pressure does not consist in the intensity of the pressure to which the steam is to be raised, but in the character and construction of the vessel which contains the dangerous element,' may be set down as a truism, containing a great deal of suggestive truth, but which is often overlooked, if not entirely ignored." "Else how is the public sense of what ought to be, but unfortunately is not, every now and then shocked by a recurrence of those accidents which result in such extensive loss of life and property." "It is the saying of one who has said many good things in his day, that 'self-interest is always intelligent.'" "In the matter of the use of boilers notoriously defective in form, material and construction, self-interest is *not* always intelligent; for however easily employers may take the loss of life from accidents in the use of steam-boilers, one would think that self-interest would prompt them to avoid, by all means in their power, the loss of property."

What are the conclusions that are forced upon us by all that has been adduced? Plainly that wrought iron is entirely unfit for steam-boilers,—that it is unreliable and unsafe to use it for such purposes, and that neither in principle nor workmanship in the use of this ma-

terial, have we advanced one step, in a century, towards making the steam-boiler, as now generally used, safe from destructive explosion. On the contrary, just in proportion as we have increased the working pressure, so have we run into greater danger; and at this moment boiler explosions are more frequent and more fatal in their consequences than ever. It is a sad condition of things that this much needed and much used force should be so little within our control. Must these mines of destruction, placed in our cities and towns, under our feet as we tread the side-walk, and all around us, threatening at every moment our very households with destruction, still hold their pent-up wrath by so frail a thread? Is there no way to safely clip the hair, and thus let the sword now hanging over our heads, fall harmless at our feet, there to lie harmless forever? I think there is a way to do this. If this can be shown, then let no one say hereafter that steam-boiler explosions cannot be prevented. Says Mr. Wm. Fairbairn, whom we again quote: "Instead of working two hundred pounds pressure to the square inch, I think we shall reach five hundred pounds." In *Engineering Facts and Figures*, for 1863, in treating of the great need of improvement in marine boilers, we find the following: "The answer is obvious,—no further economy can be obtained in steam-power without the use of *high pressure* and expansion." Ocean steamers, twenty-five years ago, used three or four pounds pressure to the square inch. Now the Cunard steamers use twelve or fifteen. Our North River and Sound steamers, the pioneers in using much higher pressure condensing engines, carry thirty or forty, and even fifty pounds to the square inch. Common consent, if not necessity, demands higher pressure, and it behooves the engineering profession to look to it, that we do not continue the present imperfect and most dangerous system, if there is any way to avoid it. It is a sad story of disaster in the past. It is meet and necessary, that the long-time reproach should be removed. Enough, we think, has been said to convince the most prejudiced that a good, safe and durable steam-boiler *cannot be made of wrought iron*. Assuming this to be proved, in what direction must we then look to find a better and more reliable material for the purpose,—one not possessing the many inherent and insuperable defects of wrought iron, one that can be readily made into such forms as will most conduce to the safety, durability and economy of a steam-boiler.

Turn we now to cast iron,—early used, but heretofore and even now, generally supposed inferior material for steam-boilers. On the subject of cast iron, a writer in the *London Mechanics' Magazine*, for May 2d,

1864, uses the following language: "There is a French proverb which says, that we always return to our first love, and it is by no means unlikely that this will be verified in boiler engineering. At one period it is beyond question that cast iron boilers were habitually used for very high pressures, and they were used because the material possessed constructive advantages which were not then believed to reside in wrought iron, and if these advantages reside in it still, under a principle of construction modified to meet existing demands, there is no good reason why it should not be habitually employed. Cast iron is far better adapted to meet the ordeal of fire and water to which a boiler is exposed than the best wrought iron plates ever manufactured. As to strength, we all know, or ought to know, that that is a matter of proportion quite as much as a matter of material. There is nothing like practical illustration to bring such truths home to the mind. Let us suppose, then, the case of two boilers, one made of plates half an inch thick, and the other one quarter of an inch thick. If each of these boilers is, say, six feet in diameter, the first one will possess, as nearly as may be, double the strength of the other. To render both of equal strength it is only necessary to reduce the diameter of the thinnest one to half the diameter of the thickest." "In the same way, it is certain that a cast iron tube, of a given diameter, may be made quite as strong as one of wrought iron of the same thickness, provided the diameters are proportioned the one to the other, in the ratio of their tensile strength. That the arguments adduced against the use of cast iron, are many and powerful, we do not pretend to deny; but that they are invariably applicable, or that it is, in other words, impossible to devise a boiler that shall elude these objections, is false." "We daily see cast iron used to carry enormous pressures with the utmost confidence. Its tensile strength may always be brought, in one sense, up to wrought iron by using enough of it. It has thus beaten wrought iron, in the form of guns, many times. There are two ways of increasing the strength of any vessel; the one in increasing the thickness, the other in reducing the diameter of the globe or cylinder to be tested. It is obvious that cast iron can only be used in small tubes or chambers, inasmuch as larger vessels must necessarily be of such a thickness that heat would pass through it very slowly indeed. But this fact in no way militates against the safety, economy or efficiency of a generator. Perhaps the present system of employing wrought iron boilers of colossal dimensions in our every-day practice, has been productive

of more injury to life and property, than can be laid at the door of the engineer on any other ground."

In a leading article in the *Engineer*, for 1864, it is said: "It has been so long the custom to consider cast iron as a brittle material, hardly to be trusted under pressure, that it requires some amount of reflection to perceive wherein it possesses manifest advantages over wrought iron. The resisting strength of a properly made cast iron boiler is calculable, and a good *a priori* case, could have been made out in its favor, long ago." What if the very brittleness of cast iron, when used in a steam-boiler, should prove an element of safety?

In an article in the *American Artisan*, for November 22d, 1865, in answer to an assertion made in that journal, referring to the Harrison boiler, that, "cast iron was not to be recommended for steam-boilers," because it "was liable to be strained from inequality of temperature," I have said, "Many years of experience in the use of this boiler has taught me that as a material for steam-boilers, cast iron is far preferable to wrought iron, and for a reason that can be very easily understood. Cast iron is *not* liable to be strained 'by inequality of temperature;' it is liable to *break* from such cause, and will give out at once if badly proportioned or improperly used. Wrought iron in steam-boilers *is* liable to be strained by 'inequality of temperature,' and not fracturing at once, goes on straining until its structure is destroyed, and the parts thus strained inevitably give way, death and destruction too often following. Put cast iron in such form as will prevent harm in case of rupture, and it becomes the *very best* material for steam-boilers, and one of its best qualities is in giving out when badly treated, a warning not to treat it so again. Not so wrought iron; its very tenacity begetting a false security which might lead to disaster at any moment." It certainly appears strange at a first glance, that such a seeming bad quality as brittleness in any material, should make it more reliable than a more tenacious one, for purposes needing strength. It would appear more strange, if this should prove true, in a material for steam-boilers.

(To be continued.)

(Continued from page 14.)

THE NEW YORK "CENTRAL PARK."

By William H. Grant, Superintending Engineer.

CHAPTER I.

ON ROADS, ROAD-MAKING AND ROAD-MAKERS IN GENERAL.

The *necessity, from remote times, for road-making; but little rest for the hand of man in the business. Long practice has not made the art perfect. Various plans tested in Park construction. Difference in cost not great between good and poor roads. A knowledge of road-making does not "come by nature." Inconsistencies of the public. Public views as to the constructive arts. Our early engineers. An unfortunate inheritance of the professión. The progress since made by the profession, and what it has done. Prejudice as to engineers' estimates and economy. A word to young engineers. Roman roads. English roads in the last century, and the improvements that followed. A new era. English road-makers. Origin of McAdam roads, and of Telford roads. Indestructible roads, as the Roman, the Russ and iron pavements, not practicable. Foundation work should be permanent. Trap-block pavement. Common roads in the country.*

The art of road-making is quite a venerable one from its antiquity. It would scarcely be a figure of speech to say it was "as old as the hills"; for, if we may believe the geologists, hills, mountains and valleys have been formed within quite a recent period—are, in fact, still in process of formation. However this may be, the transformation of the surface of the earth, from its primeval condition to its present rugged character, doubtless lies at the bottom of the business, and has been the chief provocation to the introduction and practice of the "art and mystery" of road-making. It is quite certain that, from an early period down to the present day, whether from the "upheavals," "depressions" and "denudations" of geologists, or other moving causes, there has been a constant necessity in the intercourse of mankind for making rough ways smooth, and crooked ways straight, and that there has been but little rest for the hand of man, through many successive generations, from road-making labors. It would be natural to suppose, that from long practice the art would have made such advances ere this as to have precluded the saying of much that is new or instructive in regard to it.

The multiplication of examples, experience, traditional knowledge,

treatises and theories has really been such as to make it appear a work of supererogation to attempt to add anything more upon the subject. Still, the subject has not been exhausted, and this arises from the fact that varying necessities and circumstances are constantly occurring, requiring new adaptations and new applications in the channels of human intercommunication, and the art that applies to them must therefore be progressive, and subject to improvement like most kindred arts of human origin.

A reference to past experience, ancient as well as modern, is useful to the road-maker of the present day, but it will not meet fully the requirements that will be made upon him. The supposition may be plausible, that whatever is odd and long-tried is the safest guide to follow; but something more than precedent and routine must be looked to, to meet the present and future demands of the art. Whoever sets about the work and attempts to carry it out practically, on any considerable scale, will be met by these considerations; he will find that, with all the light of the past, except that which is reflected from sound general principles, he must rely very much upon his own resources, cultivated judgment and skill, for success.

The conditions of the problem are too variable to be governed by fixed and uniform rules. Expediency, feasibility, special adaptation, questions of cost and materials, influence of climate and various other matters, will in turn, singly and in combination, arise to be passed upon. The road-maker who is not prepared to deal with them judiciously, without recourse to the rule and plummet of precedent, will often be sorely perplexed. If he is inclined to rashness, he will probably escape from the dilemma, for the time, by committing a blunder. If he takes the more prudent course he will retrace his steps from unsafe ground until he acquires the means of obtaining a safe footing.

Modern treatises upon road-making contain much that is valuable and indispensable; but, at the same time, they reveal a great contrariety of opinions, practice and results, that has been found, after a good deal of attention given to the subject, to adapt them rather to the closet of the student than to the field of the practitioner.

The writer does not, of course, expect here to supply a desideratum in these matters. Allusion is made to the facts as they have been found to exist, in order to direct attention to necessary principles and resources; and beyond this he has not the presumption to attempt to do more than give a description of his own practice (which has occurred under circumstances more than ordinarily favorable) to pass for whatever it may be worth.

The scale upon which the Park roads have been constructed, and their general object, have been favorable for testing, in a thorough manner, some of the principal modes of road-making in vogue, and for perfecting, beyond ordinary practice in this country, many of the details of the work. It was proper that these roads should be of a superior description in all respects, and that no efforts should be spared to adapt them, in the most complete manner, to the end designed. It was not only essential that this should be done as to mere external appearances and accessories, but that they should be fitted for durability, safety and easy practical maintenance. These considerations, combined with the endeavor to pursue the soundest economy, and to avoid hasty and ill-considered expedients, have governed their plan and execution. No extravagant or lavish notions have been indulged in, nor have means been misapplied in experimenting.

The expenditure incurred, though large, could not have been wisely less, so far as the actual service and permanency of the work is concerned. If it had been less, it would not have been conducive to economy in the end.

Much of the cost of the roads was, of course, for the rough grading over expensive ground, peculiar to the locality, and a good deal was owing to the unusual widths as compared with other roads, but for the work pertaining to the service and wear on the superstructure, no more cost has been incurred, proportionably to the width, than is frequently expended on roads of an inferior character; for, although it has been found by experience that it is not as easy a matter to make a good road as is popularly supposed, yet it is believed that the difference in cost between a good road and a poor one, made as the latter frequently are made, need be but very little; cases could even be cited in which it has become painfully evident that more money and hard work had been expended to accomplish a *failure* than would have been needed to ensure a *perfect success*. One reason for this has been found to be the desire on the part of the public to make cheap roads, or what are fallaciously supposed to be cheap roads, by the employment of cheap materials and cheap labor, and another is the prevalence of the idea that every man may be his own road-maker, and that all necessary knowledge of the art "comes in someway by nature."

Incompetent and unfaithful agents are employed, and the result is too frequently found to be, that the road falls into the large class of very "common" roads of the country, is a vexation and an annoyance, and, in the end, quite the reverse of a cheap one.

It is doubtless among the besetting sins of professional men to magnify their office, and attach undue importance to the knowledge and experience they have gained by long study and practice, and to proportionably underrate or distrust the abilities of others who have not in like manner qualified themselves for the duties they assume; but if this is the case, it must be conceded that there is some extenuation for it, in the striking examples of ill-success by inexperienced persons that are so frequently brought to their attention.

There is a singular inconsistency exhibited by many persons in the selection and employment of agents for various professional duties. A man, for instance, who needs the services of a physician, or a lawyer, seeks among those professions on whose science, skill and general reputation are well attested by previous success, or whose initiatory training has been such as to give a well-grounded assurance that he will ably discharge the duties of his office; but when it comes to the selection of agents for the performance of many other duties that have required an equal degree of study and practice to become proficient in them, the same individual will be found to depart from the rule, to relax his judgment and take up with the services of those whom he knows, or easily might know, have been imperfectly or not at all fitted for the duties they undertake to perform.

It is a matter of surprise that this want of discrimination is so often manifested by men of a high order of business qualifications, who, when they step aside from their routine occupations, in which they have been uniformly successful, and undertake other enterprises, seem to act upon a maxim at variance with all their previous habits.

Examples of this kind could be cited, but they have so frequently occurred that most observant persons will recall them in one form or another. Many remember them, as the writer has reason to know, to their cost, and have grown wiser by dearly-bought experience.

It might be explained, perhaps, that in regard to the constructive arts, and especially those that belong to civil engineering, popular opinion does not as yet in this country, attach the same importance to preparatory studies and qualifications as in the case of the older professions. It is scarcely fifty years ago, dating about at the commencement of the Erie Canal, that civil engineering took the position of a distinct profession among us. We had, at that time, no native engineers who were educated as such, and as a preparatory step in un-

dertaking the public canals, one or more foreign engineers were employed.*

The profession grew up with the occasion, and under great disadvantages, active and energetic men, whose theoretical and practical knowledge of the business was limited to the requirements for land-surveying, constituted the material first drawn upon.

They produced certainly very creditable results, creditable to themselves and of great and lasting advantage to the country, but perhaps not fortunately for their successors. If men could accomplish, extemporaneously, and without previous training, what they did, what need of higher culture and a long course of study and practice? Have not the public continued to reason upon such grounds until they have lost sight of subsequent progress and subsequent results, and in their admiration of the works of Geddes, Wright and others of that day, have forgotten the more perfect successes and surpassing achievements of Latrobe, McAlpine, Whistler and many others of a more recent period. There seems to be an obliviousness to the fact, that although the profession entered the lists at a late day, and had many obstacles in the way, it has made rapid advances, and, with the speed of the ocean steamer, the locomotive and the electric telegraph, has long since overtaken the more favored professions, and is prepared to keep even pace with them towards the common goal.

It would be difficult to point to any page of history that exhibits greater changes and improvements, in the same space of time, than have been wrought in this country, within the memory of the present generation, through the instrumentality of the engineering profession, rising in proficiency with the emergencies of the occasion, and elevating its standard quite up to the height attained in the older European countries.

But there is another phase in this matter of our early engineer and engineering that is not to be overlooked.

Notwithstanding the praiseworthy deeds of the pioneers of the profession, they were, alas! mortal, and they committed some errors, and although their virtues have been tenaciously remembered and acknowledged, they have not been sufficient to cover these errors up. The evil that was done by them has not been "buried with their bones."

---

* It is gratifying to be able to say that we have repaid this obligation in sending abroad many American engineers, in compliance with invitations from foreign governments, and they have done the profession much credit by their works and inventions.

They were charged with being extravagant in the expenditure of the public money, and with forming insane and visionary plans, with being untrue prophets in predicting certain financial results in connection with the fulfillment of their plans,—in short, of making delusive estimates, and besides being charged with what they possibly did do, were charged with many things that they did not do. And these things have been looked upon by many honest-minded persons, since that time, as a sort of legacy that they have transmitted in perpetuity to their successors.

It has thus become a strong conviction with many, that to undertake a piece of work requiring the employment of an engineer, is to embark in a career of extravagance and to incur an unknown outlay. An engineer's estimate is to them almost synonymous with an ascending series of expenditures ending only with exhaustion, and his plans are regarded as ingenious refinements upon the old-fashioned ways of doing things that are inconceivable or useless. The impression cannot be eradicated with such persons that an engineer cannot study or practice economy, whatever else he may do; his work may turn out to be perfect and durable, or it may not, but in any event it cannot be a success as to cost,—in other words, cannot be cheap.

This is a part of the unfortunate inheritance of the profession. It may be that modern practice, or rather, malpractice, also occasionally gives rise to some doubts and distrust, as in other professions,—no more, no less; but it is believed that the intelligent portion of the public are becoming more discriminating than to adopt exceptions, either old or new, in place of a well-established rule; for if there is any rule or basis that is fundamental, and specially attaches to the profession of the engineer, it is that it is the art of attaining with certainty, the greatest ends with the least expenditure of means. This applies not only to the mechanical means and the judicious selection and use of materials, but to manual labor in all its forms in construction, and to the immediate, as well as remote, moneyed economy of the work.

The engineer knows this, feels it and practises it at every step; it is a part of his education, and becomes a part of his nature; he never rushes upon a work without first carefully examining it, measuring it, weighing it, and sounding it and bringing out its contingencies; he "counts the cost," lays securely his foundation, and then, if he is a true engineer as he professes to be, and not a superficial pretender, he rarely fails in his superstructure.

His peculiarity of looking into things deeper than inexperienced

and unprofessional persons, is frequently the cause of creating doubts and hesitation in the minds of such persons. His business is to look on the worst side in any case submitted to him, and to develop hidden and unlooked-for difficulties, to point them out, represent them truly and prepare the means to meet them. This is a duty not always the most pleasant; but nevertheless a duty that he cannot shrink from. It is not agreeable to be always looking for defects, and investigating chances of failure and probabilities of ill-success, especially when they are not wanted to be seen, and he can only find his compensation for it, in the assured result that in the end obtains. He is not content to place himself in the position of a trader who speculates on a small capital, and must have quick returns or become bankrupt; but if properly imbued with the true aims of his profession, looks to the more slow and substantial reward that grows out of ultimate, well demonstrated and acknowledged success. If this comes in the end, well and good,—if not, he has at least the satisfaction of knowing that it is deserved, and that he has not yielded to a culpable weakness and glossed over his work for a transient object, and at the expense of future mortification.

But this is a prolific theme that is leading to too great expansion in this place, and we must take leave of it for matters more immediately pertinent, venturing only to add a word further, by way of advice, to the younger members of the profession.

Do not be alarmed at any apparent want of appreciation, nor over-anxious for immediate success or future fame. Your anxiety should be rather for thorough and substantial qualifications. If you have no cause to distrust yourself, the rest will come in due time. Cultivate a love and an enthusiasm for your profession, for if you do not enter into the spirit of it "with might and main," no success will follow; if you do not honor it, it will not honor you. If you fail to demonstrate its qualities and its power, its practical adaptation to small as well as great things, by sound and sensible practice, the public will not confide in you. Confidence is a plant of slow growth, and must be waited for patiently. Be deserving of it and you will not fail to attain it. Do not suppose that success in great enterprises alone is necessary for establishing a reputation. The watch is not to be despised because it is not as large as the town clock. A canal, a railroad or an aqueduct is a work of some magnitude, but it is made up of parts and details, each part being, as it were, a speciality in itself, and the multiplication of these adds only to the quality, not the quantity, of the

responsibility, skill or scientific attainments demanded. It is necessary to be prepared at all points. The profession is expanding with the greatly increasing demand for its application in this country, and it must be kept up to the emergency.

If it fails in its legitimate duties they will fall into other hands and bring discredit upon it, as perhaps has heretofore been the case. Demonstrate its claims to all the rounds of vocations and duties belonging to it, not by empty pretension and a smattering merely of superficial qualifications, but by the solid acquisition of fundamental principles, and by their exemplification in practice. Do this, "act well your part," and the public will not fail in the end to perceive it and appreciate it.

From the London Engineering, No. 1, Vol. II.

PINS AND EYES.

A PIN, passing through eyes formed on those parts of a machine or structure which are to be joined together, is a form of connection of most frequent occurrence, both in civil and mechanical engineering. For instance, the links of the chains of suspension-bridges are so connected, and so are the diagonals and flanges of Warren girders, whilst in machinery it forms the usual form of connection between the parts of all link-work. In all these cases, but more particularly in bridge-work, it is important that the size of the pins and eyes should be so proportioned to the strain upon them, that they be of equal strength with the parts which they connect. In machinery, where the parts are subjected to motion, sufficient bearing surface has to be provided to prevent heating, and it is generally this consideration which governs the size of the parts, those proportions which give the requisite bearing surface being generally amply sufficient as far as mere strength goes.

In those cases, also, where there is little or no motion between the parts to be joined, the question of bearing surface has more to do with the proportioning of the sizes of the pins and eyes than is commonly supposed. In such connections, the parts are almost always arranged so that the pins are subjected to "double shear," or, in other words, they must, before they fail, be broken through in two places. Under these circumstances, the area sheared through is, of course, equal to twice the sectional area of the pin, and in the case of wrought iron pins and links subjected to tensile strain, it would at first appear therefore that the sectional area of the former should be equal to half that of the latter, the resistances of wrought iron to shearing and tension being about equal. For instance, if we had two links, each with a sectional area of twelve square inches at its smallest part, and the end of one of them

was made with a double eye embracing the end of the other, then, if the resistance to shearing only had to be considered, the connecting-pin might have an area of six square inches. Whether this area would or would not be sufficient, however, would depend to a great extent upon the form of the eyes at the ends of the links. In the first place, the jaws of the double eye must be prevented from opening, and so throwing a bending instead of a shearing strain upon the pin; and, in the second place, the thickness of the eyes must be such that they have sufficient bearing upon the pin, and so do not fail from distortion. The opening of the double eye is generally prevented by means of a head on one end, and a nut, or collar secured by a pin, on the other end of the pin; but the second requirement, that of bearing surface, is very frequently neglected. In cases where, as in the links of a suspension-bridge chain, the thickness of the links is very small in comparison with their width, the bearing surface which the pins would have, if made with the proportions above mentioned, would be quite insufficient, and the consequence would be that the holes would be distorted, and the eyes torn.

When the late firm of Fox, Henderson & Co. were constructing the chains of Mr. Vignoles' suspension-bridge, over the Dnieper, at Kieff, a number of interesting experiments were tried to determine the proper proportions for the eyes of the links and the connecting-pins, and the results obtained were given in a paper afterwards read by Sir Charles Fox before the Royal Society. As the chains for this bridge weighed over sixteen hundred tons, and had to be carried from Odessa to Kieff, over three hundred miles of very bad roads, it was of great importance that all useless weight should be avoided, and consequently that no superfluous metal should be employed in their construction. For convenience of transit, the links were made twelve feet long from centre to centre of pinholes, and ten and a quarter inches by one inch throughout the part between the eyes. The eyes or heads were also one inch thick by sixteen and a half inches in diameter, and were at first pierced with holes four and a half inches in diameter for the reception of the pins, which latter had thus an area of 15·9 square inches, or rather more than half as great again as the smallest sectional area of the links. Notwithstanding this excess in the sectional area of the pins, however, they were, upon experiment, found to be quite unable to develop the full strength of the chains. The links were made from iron manufactured by Messrs. Thorneycroft & Co., from a mixture of Indian and other pig iron, and had a tensile strength of about twenty-seven tons per square inch, and each link ought, therefore, to have borne, if the pins and eyes had been properly proportioned, a strain of at least two hundred and seventy tons. Upon the test being applied to one of the links, however, it was found that it failed under a strain of one hundred and eighty tons, the head or eye tearing across at its widest part, where the sectional area was twelve square inches.

This result led to the supposition that the eyes were too small, and some experimental links were accordingly made with eyes eighteen and a half inches in diameter. These, however, were found to fail in a simi-

lar manner, the pinholes in both this and the former instance being drawn into a pear-shaped form, and the metal being bulged on that side which had received the strain. Under these circumstances it was determined to increase the size of the pins, thus giving greater bearing surface, and diminishing the intensity of the strain upon the eyes. One of the links, with a sixteen and a half inch head, was accordingly taken, and the pinholes enlarged to six inches in diameter, so that each pin had a semi-cylindrical bearing surface of 9·4 square inches instead of seven square inches, as in the former experiment; and the result of this alteration was, that the breaking strain was augmented from one hundred and eighty tons to two hundred and forty tons, notwithstanding that the head had less metal in it than before. Further experiments, subsequently made, indicated that the diameter of the pins might have been still more increased with advantage, the best proportions appearing to be those which gave each pin an area of semi-cylindrical bearing surface about equal to the least sectional area of the links. Sir Charles Fox considers that it is best to make the bearing surface slightly in excess of the proportion just mentioned, and he thus gets, for the pins of suspension-chains, the simple rule that the diameter should equal two-thirds the width of the body of the links.

As the sectional areas of the pins increase as the squares of their diameters, whereas the bearing surfaces increase only as the diameters directly, it follows that, whilst, in the case of small sizes, a pin of the requisite sectional area may give an excess of bearing surface, so, on the other hand, a large pin having the requisite bearing surface will have an access of sectional area. In cases where the pins are exposed to "single shear," the change from the one condition to the other will take place, with links one inch thick, at that size of pin, which has a semi-circumference in inches equal to its sectional area in square inches, or at a diameter of two inches; with thicker links this diameter will be less, and with thinner, greater. In pins of large size, when, in order to obtain the requisite bearing surface, the diameter is made much larger than would be necessary to give the proper sectional area, the dead weight may be diminished by making them hollow, care being of course taken that the thickness of such tubular pins is sufficiently great to prevent any distortion taking place when strain is applied to them.

In determining the proportions of the eyes through which the pins are passed, it must be remembered that the strain upon the metal composing them is not uniformly distributed, the stress being more severe upon the inner parts than upon the outer. To compensate for this, Professor Rankine advises that the sum of the sectional areas of the two sides of an eye should be made one-half greater than would be required if the strain was uniform. The experiments on the links for the Dnieper Bridge, above mentioned, show, however, that a less proportion than this is sufficient. The links tested had, when fitted with the six-inch pins, but five and a quarter inches of metal on each side of the pinhole, whilst the body of the link was ten and a quarter inches broad; and, under these circumstances, the breaking strain was two hundred and

forty tons against about two hundred and seventy tons, which, according to the trials of the iron, would have been required to break the link through the body. From these results, Sir Charles Fox estimates that the sum of the widths of the two sides of the eyes should be about ten per cent. greater than the width of the body of the links, this rule, of course, referring to those cases in which the link and eye are of uniform thickness throughout.

When circumstances will allow of its being done, the best way to obtain the requisite bearing surface for the pins connecting links of small thickness in proportion to their section, is to increase the thickness of the eyes beyond that of the links themselves. This allows the metal around the eye to be made narrower, and it thus consequently diminishes the inequality of the strain throughout its section. Where the links to be connected are of square section, or are of considerable thickness in proportion to their sectional area, this thickening of the eyes becomes unnecessary, as sufficient bearing surface is given without it. A rule, for the size of eyes, which has been much used, and which gives generally very good results, is to make the outside diameter of the eye equal to twice the diameter of the pin passed through it, and then to increase the thickness until the requisite sectional area is obtained.

From the London Mechanics' Magazine, November, 1866.

OVERHEATED STEAM-BOILERS.

A PARAGRAPH has just been going the round of the papers, to the effect that, recently, when the fireman at the Agnes Main Colliery, Barnsley, went to attend to his fires, to get the steam up, he observed that the float belonging to one of the boilers was down; and, on making an inspection, he found that the sluice-valve had been opened and the whole of the water run off. Although this was a villanous act, if wilfully done, yet we cannot help thinking that an unnecessary degree of sensationalism has been imparted to the circumstance by the various headings given to the paragraph in question, and by the further statement that, as the plates of the boiler were red-hot, had the fireman turned the water on before he made the discovery, there must have been an explosion and, no doubt, loss of life, as several persons were in the immediate neighborhood of the boiler. Granted, that the plates of the boiler were red-hot; but we certainly think there would have been no explosion, much less loss of life, had the fireman turned on his feed-water. This may appear a somewhat startling opinion to advance, and yet it is one which can be supported controversially, and, what is more, is recorded to have been established practically. Let us see, then, how stands this theory of steam-boiler explosions, which generally goes under the denomination of overheating. A great number of boiler explosions

are attributed to overheating; in fact, some theorists go so far as to assume this as the general cause of such catastrophes. Now, this theory, taken in a broad sense, is a false one, although it is possible that a boiler may be exploded by the formation of a great quantity of steam from water thrown upon red-hot plates. But a consideration of some of the phenomena of heat, places this possibility at the very farthest limit, and the occurrence of an explosion from such a cause only just within its bounds. We quench the heat of a railway tyre in a cistern, and why may we not as safely fill a red-hot boiler with cold water? It is surprising to see how small a quantity of steam is disengaged when a large body of wrought iron is plunged into twice or thrice its weight of cold water. Now, if we reverse the operation and dispose the same weight of metal in the form of a boiler, heat it to the same degree, and throw the same quantity of cold water into it, is it not reasonable to expect that exactly the same amount of steam will be produced? If so, where would be the harm done to the boiler beyond the damage inflicted upon the iron by burning?

If we look into the matter a little more closely, we shall find that the metallic plates of a steam-boiler are not capable of containing sufficient heat to change a very large quantity of water into steam. The total quantity of heat which would raise the temperature of one hundred weight of iron through one degree, would, according to the best authorities, impart the same additional temperature to twelve and a half pounds only of water. And this makes it clear that overheating is not the sole cause of an explosion, although it may lead to a rupture by weakening the plates. So much for the theory, which certainly is opposed to the doctrine propagated in the paragraph to which we have alluded. Much more so is practice in the matter, which leads us to believe that an empty boiler, however much it may be overheated, may be filled with water with perfect impunity. Indeed, it is on record that this has been done; and this was the experiment: An empty boiler, twenty-five feet long and six feet diameter, and with the safety-valve loaded to sixty pounds per square inch, was made red-hot. Whilst in this condition, the feed was suddenly let on and the boiler filled up. The experimenters anticipated a mighty explosion, for which they were fully prepared, but no such event occurred, the result being simply a sudden contraction of the overheated iron, which allowed the free escape of the water at every seam and rivet as high as the fire-mark extended. Although we were not witnesses of the occurrence, yet, arguing upon the hypothesis regarding the action of heat already referred to, we cannot hesitate to accept the fact; the more so in that we have heard of other experiments of a similar character having been made, and which were attended with similar results. The conclusion, therefore, is, that although at the Agnes Main Colliery a diabolical act has doubtless been committed, and one for which the offender should be made to suffer severely, yet no greater damage than has been done could have accrued, had the fireman turned the feed on. The result would most probably have been a rapid cooling and contraction of the plates, and, when the water reached a sufficient

height, the extinction of the fire. This may appear an unsatisfactory conclusion to some of our contemporaries, who would have the fireman and his co-workers raise a hymn of praise for deliverance from an awful catastrophe. It is, however, the only legitimate conclusion to which we can arrive upon a consideration of the known laws of cause and effect. Moreover, it is the teaching of science, the laws of which are fixed and immutable, and its facts the stubbornest of all stubborn things.

Whilst on the subject of steam-boiler explosions, we may as well pursue the matter a little further, with regard to the cause of their violence. Many theories as to the cause of the violence exhibited have from time to time been called into existence by the characteristics attending various steam-boiler explosions. Some of these find support in circumstances which are fatal to others, and *vice versa*, while most of them are open to the entire objection from their inconsistency with certain fixed laws of cause and effect. We do not, however, purpose now to travel over old ground, nor to reopen questions long since set at rest. We will content ourselves by observing in passing, with regard to the various theories, that the percussive force of steam alone is incapable of producing the destruction attending most steam-boiler explosions. Overheating, with which we have already dealt, cannot be assumed as the general cause, for explosions have often taken place when, but a moment before, the water-gauges indicated an ample supply of water. We have seen that a boiler has been even filled, while red-hot, with water, but no explosion took place. The electrical hypothesis, so fondly indulged in by some, is perfectly untenable, for it is impossible for electricity, if generated by ebullition or in confined steam, to collect within a boiler, which is in direct communication with the earth. That the decomposition of steam is a cause of the violence—or even of explosions at all—is negatived by the fact that the decomposition of water by heat on a large scale, for the purpose of applying its elementary gases separately, has generally been attended with very unsatisfactory results. Thus we work round to our starting point, and ask, To what cause shall be attributed the violence attending a boiler explosion? This proposition is, to our mind, most effectually met by the theory advanced by Mr. Zerah Colburn some six years since, and which subsequently formed the subject of some discussion in our columns.

In all boiler explosions, the pressure of steam is instantaneously liberated from the surface of the hot water present. Assuming the boiler to be at work at a pressure of forty-five pounds, the water will be at a temperature of about two hundred and ninety degrees. Now, fresh water cannot for an instant be maintained at a temperature much greater than two hundred and twelve degrees, under the ordinary atmospheric pressure. If, therefore, the pressure upon it be suddenly liberated, when heated to (say) two hundred and ninety degrees, a most violent disengagement of steam, and projection of water along with it, must inevitably take place. The shells of boilers are constantly liable to rupture from original unsoundness of the iron, bad riveting, corrosion by bad water, or furrowing. This being the case, what are we to expect when

the opening of a weak point suddenly liberates the steam pressure from thirty, forty or even sixty tons, of heated water, which are waiting below to burst partly into steam? To render the matter perfectly intelligible, we will state the distinct and consecutive operations into which, according to Mr. Colburn, a boiler explosion, although practically instantaneous, may be resolved. They are, first, the rupture, under hardly, if any more than, the ordinary working pressure of a defective portion of the shell of the boiler—a portion not much, if at all, below the water-line. Second, the escape of free steam from the steam-chamber, and the consequent removal of a considerable part of the pressure upon the water, before its contained heat can overcome its inertia and permit the disengagement of additional steam. Third, the projection of steam, combined, as it necessarily must be, with the water, with great velocity, and through a greater or less space, upon the upper sides of the shell of the boiler, which is thus forced completely open, and perhaps broken to pieces. Fourth, the subsequent disengagement of a large quantity of steam from the heated water now no longer confined within the boiler, and the consequent projection of the already separated parts of the boiler to a greater or less distance. This unique theory harmonizes so well with the circumstances of steam-boiler explosions, that we can but admire and accept it. It is so consistent with all the phenomena attending these explosions that it leaves no room for doubt or questioning as to its soundness. It receives support from the well-known fact that boiler explosions frequently take place at the starting of the engine, when there is a sudden withdrawal of pressure in the boiler. The most conclusive evidence of the soundness of the theory, however, would be suddenly to condense steam in the steam-chamber of a boiler at work and to watch the results. If a boiler were half filled with water, and the steam got up to thirty pounds or forty pounds, and if a quantity of water were suddenly thrown into the steam-space, the steam would be suddenly condensed, and an explosion of the boiler would doubtless follow. Such an experiment would, of course, be attended by considerable danger, and the object gained would probably, after all, be very inadequate to the risk involved. It seems to us, however, that the question has just been practically solved, and the only evidence wanting actually supplied, although under most distressing circumstances. We allude to the recent loss of the *Ceres*, in the reports of which catastrophe it is stated that the sea rushing suddenly in upon the boilers caused them to burst with fearful results. If this be correct—and all accounts agree upon the point—here is a singular though melancholy confirmation of Mr. Colburn's theory. The cold water suddenly cooled the boiler-plates, condensed the steam in the steam-space, relieved the pressure on the lower part, and forthwith the steam and water from below burst forth with resistless energy upon their errand of destruction.

From the London Engineering, No. 51.

GRINDING TYRES.

It is a fact well known to locomotive engineers that steel tyres, after they have been some time in use, become greatly hardened on their bearing surfaces, and that, in fact, a kind of hard skin is formed on them which it is frequently exceedingly difficult to remove by the ordinary process of turning. This more particularly happens in tyres which are subjected to the action of brake-blocks, as, for instance, in the case of those of tank-engines and tenders, and it has led to the manufacture of several classes of tool steel specially intended for turning them. In some cases the plan has been adopted of breaking up the hard skin of the tyres by means of a hammer having a blunt cutting-face, the cuts made by this hammer enabling the point of the turning tool to be got under the skin. This plan enables the difficulty to be got over in the greater number of instances, but the process of turning is necessarily a slow one, the speed of the lathe having to be reduced below that ordinarily employed.

During the time that Mr. (now Sir Daniel) Gooch was locomotive superintendent of the Great Western Railway, he extensively employed on that line composite tyres formed of iron faced with steel, and as the latter was hardened, it was impossible to turn them in the usual way. This led to the use of machines for grinding the tyres, and several of these machines have been successfully at work at Swindon for many years. At present their application is not confined to hard steel tyres, but they are partly employed on other tyres also, and it is probable that they will be used still more extensively. They each consist of a bed-plate carrying a pair of centres, between which the wheels, of which the tyres are to be dressed up, are placed; and they are furnished with a couple of rests, similar to those of an ordinary wheel-lathe, but each supporting a small grindstone instead of a tool-holder. These grindstones are run at a good speed by means of a simple arrangement of belting, and the wheels which are being dressed are made to turn in the opposite direction, by means of a belt passing over a pulley temporarily fixed on the axle. The grindstones can be moved either laterally or to and from the wheels, like the tools of an ordinary lathe, and the dressing up of the tyres is entirely completed by them.

In the case of tyres which could be easily turned up in a lathe, the cost of dressing them by grinding is found to slightly exceed that of turning, but in the case of very hard tyres it is considerably less. At Swindon, Mr. Armstrong is about to fit up a tyre-grinding machine with four stones, two stones being made to act upon each tyre like the tools of one of Whitworth's duplex lathes, and it is expected that by the use of this machine the cost of grinding a pair of tyres will be reduced below that of turning them in all cases. The tyre-grinding machines turn out excellent work, the finish being quite equal to that obtained in the lathe, and the correct section of tyre being accurately formed.

Although we believe that the practice of grinding tyres has been carried out more extensively at Swindon than it has been elsewhere, yet tyre-grinding machines have been used to some extent at other railway works,—for instance, at those of the London and South-western Railway at Nine Elms, those of the Great Eastern Railway at Stratford, and some of the railway shops on the Continent. Except in the case of those at Swindon, however, the use of the tyre-grinding machines has been confined in most cases to the removal of the hard skin of the tyres only, the tyres being afterwards finished in the lathes in the ordinary way. The Swindon system is much more economical, and there is every reason to believe that tyre-grinding machines of some form or other will be eventually found amongst the workshop plant of all lines upon which steel tyres are used.

From the London Engineering, No. 1, Vol. III.

BOLTS AND NUTS.

To RECOUNT the numerous ways by which the two simple and most indispensable elements of machinery—bolts and nuts—are manufactured, and the different tools used for the purpose, would occupy a volume of very considerable size, and of, perhaps, no small value to a limited number of persons. Bolt and nut making has become a large and valuable trade of itself, and many extensive works, such as the Bolt and Nut Company's works, at Smethwick, the Cleveland Bolt and Nut Works, at Middlesborough, and others, are constantly occupied in the manufacture of this speciality. The great bulk of the bolts and nuts, however, manufactured in these works for sale, are of the kind commonly called "rough," while the "finished" bolts and nuts, or those which are cut and shaped to great nicety in the thread as well as on the sides of the nut and bolt-head, are generally produced by the engine-builders who use them, engineers being as yet disinclined to entrust the accurately finished work they justly lay so much value upon, to other parties. Machines for finishing bolt-heads and shaping nuts are, therefore, an universal requisite in engineering works. One of the oldest and most successful types of nut-shaping machines has a pair of revolving cutters set to a distance apart corresponding to the width of the nut or bolt-head to be acted upon, this nut or bolt-head being passed between the cutters, either in a straight line, as in Mr. Whitworth's machines, for instance, or in a curve, as in the tools designed by the late M. Borsig, and which are still at work in his factory, at Berlin. In the exhibition of 1862, Mr. Hartmann, of Chemnitz, produced a very neatly designed machine for shaping nuts, made on the principle of a duplex slotting-machine, and this machine (the manufacture of which, in England, has been taken up by Messrs. Sharp, Stewart & Co.) was illustrated and described in this journal, at page 183 of the present volume. An excellent nut-shaping machine, and one capable of producing a large

quantity of beautifully finished nuts, is now in use at Messrs. Clayton, Shuttleworth & Co.'s works, in Lincoln, the machine being designed by their manager, Mr. Wilkinson. The nuts are screwed, in numbers of four to six, upon bolts, placed radially into a revolving head-stock, and are, in their rotation, passed first between two cutting-tools, fixed in a slide-rest, at a distance apart slightly in excess of the finished side; and then, on the opposite side, after completing half a revolution, they are operated upon by a pair of finishing tools, set so as to reduce the nuts to the exact size required. The nuts, by this process, acquire a very pretty appearance on their outer surfaces, owing to the curved tool-marks left by the action of the machine, and they are finished with great accuracy. It is said that a number of about one hundred nuts, when placed upon a table side by side and tied round with a string, can be lifted off together, and will not fall asunder when removed from the table. This, it need hardly be remarked, would be a test proving a degree of correctness and accuracy equal to the best engineering workmanship in existence. Attempts have been made to forge bolt-heads and nuts to such a nicety as to do away with tool-shaping altogether. To produce a nice, clean surface, the nuts and bolt-heads have been hammered cold, and articles of very good appearance have been produced by this process; but the iron, being operated upon at a low temperature, became brittle and crystalline, and the bolts and nuts showed the faults peculiar to that molecular structure. The brittleness of these cold-hammered bolts and nuts can be removed by subsequent annealing, but then they again lose the smooth surface; so that, practically, they are not much superior to the "rough" bolts and nuts of the trade coming from a first-class maker, and for which the name "rough" is certainly an unsuitable term, if taken at its proper meaning. Bolts and nuts, in great numbers, are cast with threads complete, by some manufacturers. Mr. E. H. Benthal, of Heybridge, casts bolts and nuts with such nicety and cleanness in the thread of both, that they fit and work into each other with an ease and correctness which cannot fail to cause some degree of astonishment. The threads are, of course, moulded from cut bolts in the first instance, and the preparation of moulds and cores requires great skill and experience; but, by practiced workmen, the work can be carried out with perfect success, and the bolts and nuts so made, can be advantageously used for many kinds of agricultural implements and machinery, or for articles of a similar nature.

The advocates of division of labor amongst engineers—and they form a very strong majority in the profession—will perhaps endorse the opinion originated by a mechanical engineer of great practical experience—that a manufactory for finished bolts and nuts, fitted out with the most improved machinery for screwing, shaping and finishing, and carried on upon the strict principle of producing nothing but the highest class of work, would be a great advantage to engineering works in general, and would find favor with engineers in the same degree as their confidence in the accuracy and good quality of the work produced should be justified by experience. The uniformity of thread introduced by Mr.

Whitworth's standard, and the great benefit derived from it by mechanical engineering at large, is, to a great extent, favorable to such a system of manufacture, and would enable works laid out for it to keep a stock of all standard sizes of finished bolts and nuts, which might be supplied cheaper, and, if not better, certainly as well finished as in the best machine-shops existing. Their manufacture, when thus carried out on a large scale, would receive more of the undivided attention of practical men than can be bestowed upon this single subject in large works, where it forms only one of the numerous accessories of the general business, and has to be carried on, so as to least interfere with the main bulk of the work.

From the London Engineering, No. 29, Vol. II.

ROAD TRACTION ENGINES.

WITH the change of Ministry there is every probability of a relaxation of the obstructive and mischievous legislation on steam traction engines. For these there is a large and increasing demand, since by means of them, work can be done at half the cost of horse-power. The first of a number of traction engines required by the Ottoman Carrying Company has recently been turned out by Messrs. Dübs & Co., Locomotive Works, Glasgow, to the designs of Mr. D. K. Clark, C.E., embracing the Bray driving-wheel and many points of novelty which have been protected by patents. The engine is intended for service in Syria, between Damascus and the port of Beyrout, a journey of sixty-eight miles, across Mounts Lebanon and Anti-Lebanon, and is to carry ten tons of goods over steep inclines of one in twelve, and others scarcely less steep, at the rate of from three to five miles per hour. This engine differs in several important particulars from the ordinary construction of traction engines. These have for the most part been made, as a *sine quà non*, cheap, after the model of the common portable engine, for agricultural purposes, combining the means of occasionally taking a load across a field or along a country road, with the means of driving machinery. But in the new engine, which is supported on bearing springs, a strong frame is constructed expressly to carry the boiler and the whole of the machinery, also to bear all the stress and fatigue incidental to the hauling of heavy loads on common roads. By means of a compact differential motion, the engine is enabled to turn the quickest curves, with a train behind it, with the greatest facility, the outer driving-wheel being, by self-acting means, enabled to revolve faster than the inner one, as in an ordinary carriage or wagon. Thus, the whole tractive power of the engine is available in turning the curves, getting rid of the stress and loss of power caused by the inevitable slipping and grinding of engines not so fitted. The machinery is arranged horizontally beneath the boiler, and thus a

very simple and compact system of framing has been matured. The Bray teeth, which are applied to the driving-wheels, are formed hollow, so as to receive the thrust of the teeth-rods inside, and thus to avoid the tilting action of a thrust on end. By means of these and other specialities, Mr. Clark has endeavored to combine great strength and lightness with efficiency and durability; at the same time the cost is moderate. The engine carries five hundred gallons of water and fifteen hundred-weight of coal, and when tested with the regulation load of ten tons, carried in two wagons over the steep inclines of the Cathcart Road, near Glasgow, she ran at an average speed of four and a half miles per hour, going and returning, the prevailing gradient being one in thirteen and a half, on a macadamized surface. The maximum speed was about six miles per hour, equal to that of a London four-wheeled cab. The engine has been solidly constructed of the best materials and workmanship, and has been beautifully finished, to the great credit of the young, but already celebrated, firm of Messrs. Dübs & Co. This, the first traction engine constructed for the Ottoman Company, is named the *Abdul Aziz*.

HYDRAULIC RAM OBSERVATIONS,

FOR USEFUL EFFECT.

OBSERVATIONS BY GEN. H. HAUPT, OCT. 10, 1866,—CHESTNUT HILL.

Reduced and compared by HENRY CARTWRIGHT, ESQ.

HEAD of water to Ram, 8·812 feet.

Discharge of water per minute, 768 cubic inches = 3·31 gallons of 231 cubic inches = 27·73 pounds.

Diameter of drive-pipe, $1\frac{1}{2}$ inch × 15 feet long.

Diameter of delivery-pipe, $\frac{3}{4}$ inch × 200 feet long.

Horse-power of water to Ram, ·0074 = $\frac{1}{130}$ horse-power,

$$(27{\cdot}73 \times 8{\cdot}812 = \frac{244{\cdot}35}{33{,}000} = {\cdot}0074 \text{ horse-power.})$$

Height of delivery, 63·4 feet.

Delivery per minute, 48 cubic inches = 1·736 pounds.

Delivery per five minutes, 1 gallon.

Strokes of Ram per minute, 170.

$$\left.\begin{array}{l}1{\cdot}736 \text{ pounds} \times 63{\cdot}4 \text{ feet} = 110{\cdot}06 \text{ pounds, one foot high,} \\ 27{\cdot}73 \text{ pounds} \times 8{\cdot}812 \text{ feet} = 244{\cdot}35 \text{ pounds, one foot high,}\end{array}\right\} \text{the}$$

effect produced is ·45 per cent. of power expended.

Mechanics, Physics and Chemistry.

THE HOLTZ MACHINE.

A SIMPLE, CHEAP AND EFFICIENT FORM.

By H. Morton, Ph.D.

As has been mentioned in a previous number of this *Journal*, the Holtz machine, manufactured by Ruhmkorff, and secured for me at a very early period by Mr. James Swaim, now resident in Paris, after working in a very satisfactory manner for some weeks, suddenly gave out and failed to produce any useful effect.

A series of experiments, which followed, served to demonstrate that this failure resulted from a loss of insulation in the edges of the paper strips attached to the fixed plate. And this fact, together with its remedy, (found in giving the papers extra insulation at their edges,) was published in this *Journal*, page 421, Vol. LII.

At that time the expedient of turning the plate around, so as to have the papers on the outside, and thus secure the glass plate itself as a means of insulation, was tried, but not found satisfactory, owing, as is now believed, to accidental causes, such as dampness, hasty adjustment &c. The result obtained was however, so little excellent that all thought of adopting such a method was abandoned.

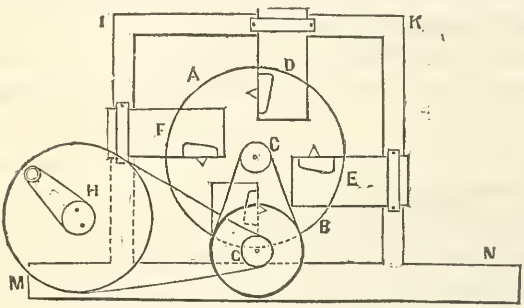
A few days since, however, in showing the machine to Mr. Robert Briggs, I set the plate in this way to illustrate certain actions, and the weather being very dry and adjustment good, found the effect far better than was expected; in fact *so* good, that the machine was run for a long time and with great satisfaction, in this way. We can therefore recommend this plan for adoption whenever a machine loses effect by leakage. If the fixed plate is reversed and adjusted as close as possible to the other, all the quantity effects can be obtained as before, the length of spark only being shortened somewhat.

On the same occasion, while discussing with Mr. Briggs the theory of this machine and the modifications of M. Bertsch, this gentleman proposed to abandon the fixed plate and substitute for it four plates of vulcanite, supported in a frame, which he sketched on the spot, and proposed to have made and send to me as soon as possible. In due course the frame arrived, and pending the preparation of the vulcanite

strips, which were not ready, I arranged four plates of glass, such as I use for drawings in the lantern, with strips of paper such as are found in the ordinary Holtz machine. These I supported in the frame opposite the collecting points, and much to my satisfaction, found the machine in this *cheap* form to work with quite as great effect as in the delicate and costly construction with the five-windowed plate of glass.

This result was naturally to have been expected, the office of the glass plate being merely to afford an insulating mechanical support to the paper strips, (according to the theory of the machine which I have before published).

The exact method of arrangement is indicated in the accompanying figure, where I, K, M, N represents the supporting frame, and F, D, E, C the glass plates; while the revolving glass disc is shown at A, C, B, and the pulleys and crank, to give it motion, at CC and H.



The advantages of this form are manifest, including cheapness of construction, ease of transportation and repair, capacity of modification; two, three or four elements, or a larger number, being easily applied or removed, as occasion requires. By placing the papers on the outside of the glass, the great difficulty of securing thorough insulation to their edges is removed, and a few coats of varnish, hastily applied, render them efficient.

HOW TO SELECT LUBRICATING OILS.

In selecting sperm oil for fine machinery, a small quantity should be poured on a polished steel plate. If it corrodes the plate, as some samples will, it should not be used. There is sometimes a trace of acid in the oil. . . .

Translated for the Franklin Institute Journal from the Comptes Rendus, Vol. LXIII., p. 881.

A FURTHER MODIFICATION OF THE HOLTZ MACHINE.

By M. A. Piche. Communication by M. de Parville.

In the *Compte Rendu* of November 5th, M. Bertsch gives a description of a new electrical generator or continuous electrophorus. I also have described, in several journals, on the 21st of January last, an apparatus which appears to me similar to that of M. Bertsch. The inventor, M. A. Piche, has published a note on the subject, with a drawing to explain it. I now have the honor of showing this, to the Academy.

M. Piche discovered his rotating electrophorus in trying to simplify M. Holtz's machine. I here give a concise description of it:

A single disc of strong paper, thirty centimetres in diameter, is mounted on an axle of isolating material, a glass tube for example, that is caused to rotate between convenient supports, by means of a handle and two pulleys with an endless band. In front of the disc there are two collectors with metallic points, symetrically placed with regard to the centre. These copper wires, which are at first perpendicular to the plane of the disc, turn at the ends vertically, one towards the bottom, the other towards the top, so as to approach each other, and they terminate in two movable balls.

To charge the apparatus, you take a piece of paper which has been well dried by the fire, and rub it; then place it at the opposite side of the disc. You then rotate the disc, and you will perceive between the two balls a luminous jet, the sparks of which are continuous, and give out ozone.

By covering the disc with shellac, and placing in front of the second collector, another piece of paper charged with opposite electricity to the first, it produces more intensity in the experiment, and causes it to last longer. You obtain with this rudimentary apparatus sparks of five centimetres in length, when the experiment is successfully performed.

If you connect the two balls with the armatures of a Leyden jar, the jar is rapidly charged, and if you bend the copper wire so that the jar will discharge itself, you can obtain forty discharges without rubbing the paper again.

It is only necessary to compare this short description with that of M. Bertsch, to be convinced that the two pieces of apparatus are similar, having the same principle and the same result.

M. Bertsch writes: "A disc, formed of a sheet of isolating material, is mounted on an arm of the same material, and can be turned by a handle or treadle, with the rapidity of ten or fifteen turns a second. Two collectors with metallic points and without communication between them, are placed perpendicularly to the plane of the plate, and serve to exhibit the double current which is created." And further on: "Behind the plate, and parallel to its plane, you can place, if desired, one or many sectors, or thin sheets of isolating material, not in contact with the last, but at a short distance from it," etc. "To start the machine, it is sufficient to rub one of these sectors very lightly with the hand, which excites its surface, and to place it in the indicated position; the wheel then being put in motion, a series of sparks springs between the two electrodes without interruption," etc.

M. Piche constructed his machine, with a trifling cost, with paper, glass tubes, corks and copper wires. M. Bertsch has made a scientific instrument, but it appeared to us that it was not without interest, nor even without importance, to enter into these details of the other apparatus.

From the London Journal of the Society of Arts, No. 689.

(Continued from page 46).

CANTOR LECTURES—SUBMARINE TELEGRAPHY.

By FLEEMING JENKIN, Esq., C.E., F.R.S.

But although from these tables it appears that the Atlantic cable might be lifted by sheer pulling, this course is not advisable owing to the extra strains produced by the heave of the ship, the resistance to displacement by the water, the friction of the water, possible currents of water, the possible drift of the ship to one side of the cable, and the possible existence of a weak point in the cable. Owing to all these elements the practical chances of success by sheer pulling are very small. It has been proposed to lift the cable by a number of ships, acting like so many piers to a suspension-bridge. It is difficult to suppose that they would keep their respective positions accurately, or all haul in at the proper rate. It has also been proposed to catch the cable at one point, then at another nearer the end, then to drop the first grapnel, and catch the cable

again nearer the end, and so, working hand over hand, reach a point at last so near the end that the cable could be lifted nearly vertically. This is better than the last plan, but is unnecessarily complicated, and the cable might easily be injured in the attempts to catch it at so many points. The simple plan which at once occurred to all practical men, is to catch the cable with one ship by holding grapnel, and then to cut it with a grapnel from a second ship, some three miles to seaward; the loose end held by the first ship could then be hauled on board with little strain. This plan will probably be adopted, with much chance of success. It is certain the cable *was* caught, and probably it can be hooked again; if so, there should be no difficulty in raising it, unless it is rusted to a much greater extent than we have any reason to expect. The grapnel of the first ship should be a holding grapnel, of which several models were shown, otherwise the loose end might fly back over it if the second ship cut too near the first. The second ship should have a cutting grapnel, of which models were also shown, lest if the attempt were made to break the cable by brute force it might break at an inconvenient point. Mr. Latimer Clark's grapnel, which would answer either of these purposes, was exhibited. The cable when hooked, releases a catch, allowing a block, to which the grapnel rope is attached, to be hauled up the shank, pulling round two right and left hand screws by two steel bands; the screws close the jaws which grip the cable or cut it; or one grapnel may be made both to cut and grip the cable. The grapnel can lie in only two positions, and if dragged in the proper direction, cutters placed at two diagonally opposed corners would cut the cable certainly to seaward, and the jaws hold the landward end. A simple form of holding grapnel, conceived by Mr. Carpmael, Jr., was shown; in this the cable is jammed between the prongs and a kind of half bollard. A holdfast or cutting grapnel, designed by the lecturer, was also shown. Each prong is hinged on a pin projecting beyond the shank, and the prong is so shaped at the root that the cable, when on it, closes the prong tighter and tighter on itself, whereas the end of the prong, when dragging through sand or mud, is opened like a Trotman's anchor.

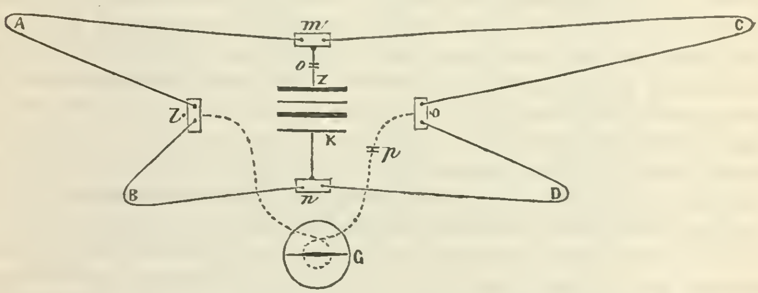
LECTURE IV.—ELECTRICAL TESTS.

1. *Terms used.*—In order to understand electrical tests, it is chiefly necessary to have a definite conception of what is meant by electrical resistance. When the two end-plates of a voltaic battery are joined by a wire or other conductor, an electric current flows through the conductor, the presence of the current being shown by the power the wire has acquired of deflecting a magnet in its neighborhood. The magnitude of a current is simply proportionate to the force with which it acts on a magnet (*cæteris paribus.*) Thus, a magnet hung inside a coil of insulated wire, is called a galvanometer, or current measurer, since it may be said to measure the current by the deflection of the magnet. When this deflection is small, as was the case with the instruments exhibited, in which the deflection of the magnet was indicated by the

motion of a reflected ray of light, the deviations of that ray of light, from its normal position, may be considered as true relative measurements of the current producing that deviation. The battery may be looked upon as a constant source of power, and the conductor as a kind of pipe conveying the current of electricity. The magnitude of the current depends, with a given battery, on what is called the resistance of the circuit. If the wire be small and long, the current will be feeble, and the resistance of the circuit is said to be great. If the wire be short and thick, the resistance will be small. The resistance of a conductor is the property in virtue of which it prevents a given battery from producing more than a given current, precisely as the resistance of a pipe to the passage of water might be defined, as the property in virtue of which it prevents the passage of more than a certain current of water with a given head. The resistance of conductors varies, not only with the dimensions, but with the materials of which the conductor is composed; and this resistance can be measured, *i.e.*, compared with the resistance of any other given wire, in virtue of Ohm's law, viz: that the current through a given circuit is inversely proportional to the resistance, and directly proportional to the force producing it. That force is constant with a given battery, so that if we find our current halved by the introduction of a certain wire into a circuit, we may be sure that the resistance of the circuit is doubled; but in making that calculation we must take into account the resistance, not only of the wire, but of the measuring instrument and of the battery. When this is done the old distinctions of quantity and intensity currents will be found unnecessary, and, indeed, false, since a current has but one measurable property, viz: its magnitude or strength. A current existing in a circuit which already includes a considerable resistance, is what used to be called an "intensity current." A current in a circuit which includes no considerable resistance, is what used to be called a "quantity current." The first is little affected by the addition of a resistance which may almost wholly annihilate the second. A convenient method of measuring the resistance of a battery, due to Professor Thomson, is given in Appendix II. By the simple application of Ohm's law, we might compare the resistances of two wires by observing the relative effect which they produce in a given circuit; but this is inconvenient, and hardly admits of such accuracy. The battery may vary, both as to force and resistance, during the two tests, and even if constant, the accuracy of the observation will be limited by the accuracy with which a deflection can be observed. More accurate practical tests have, therefore, been invented to measure and compare the resistance of conductors.

Tests of Conductor.—Every test used is a test of resistance, and all depends upon Ohm's law above cited. The instruments may be much varied, but the most convenient is probably that known as "Wheatstone's Balance or Differential Measurer. Let four wires be joined with a galvanometer and battery, as in Fig. 1. Then, if A, B, C and D represent the resistances of the four wires, no current whatever will

pass through the most sensitive galvanometer when $\frac{A}{B} = \frac{C}{D}$; but if the ratio $\frac{A}{B}$ be a little larger than $\frac{C}{D}$, a current will pass through the galvanometer in one direction. If $\frac{A}{B}$ be smaller than $\frac{C}{D}$, the current will be in the opposite direction. An explanation of this fact will be given in the ensuing lecture. Four wires thus arranged allow us to measure the resistance of any one of them which is not known, in terms of the three others: If A and B are equal, we may try how great a length of D is exactly equal in resistance to C, a selected standard, and this is precisely the test adopted to choose copper of small resistance or good conducting power. C is, say one hundred inches of copper wire, known to be good. Then the observer tries how great a length of copper wire from a new hank must be inserted at D to bring the galvanometer to zero, or no deflection. If this length be one hundred and five inches, the new hank is five per cent. better in quality than the standard. If the length be ninety-five inches, then the new hank is five per cent. worse in quality than the standard. But this is not all. If we desire



to measure a coil of wire having ten times the resistance of C, we may make B exactly ten times A, and then when we have adjusted the length of the wire D, so that the galvanometer is at zero, we may be sure that the resistance of D is ten times C. Hitherto we have spoken of comparing two random wires; but it will clearly be convenient to have some common term of comparison, such as the foot for length, or the pound for weight. With this view the resistance of a certain piece of wire is chosen as the unit, and when other wires are measured, instead of being always directly compared, they are each compared with the unit, and are said to have each so many units of resistance. Several units have been proposed. The lecturer uses that known as the British Association unit, sometimes called the "Ohm." When a unit has been chosen, whether for length, weight or electrical resistance, it will always be found convenient to have multiples of the unit for measuring large quantities and fractions of the unit for comparison with small quantities. With this object separate pieces of wire, equal

to 1, 2, 3, ... to 1000, or even 10,000 units, are prepared in cases, and conveniently arranged, so that any resistance required can be selected and inserted in the required circuit. These cases of graduated wires are called sets of resistance coils, and are variously arranged by the different makers. Mr. C. W. Siemens and Messrs. Elliott Brothers, both make sets of British Association coils. If, when possessed of such a set of coils, we receive a wire of which we do not know the resistance, we may arrange a Wheatstone's balance, in which two equal coils are connected, as at A and B. The new wire at D, and the set of coils at C. We then find by trial the number of units required to bring the galvanometer to zero. If we find D too small to be conveniently measured thus, we may choose two coils equal to 1 and 100 for B and A. When the galvanometer is at rest, on completing the circuit, the resistance of D will be the hundredth part of the coils included at C. Similarly, if D be large we may make the coil A 1, and B 100; then the resistance of D will be one hundred times that of the coils required at C to bring the galvanometer at zero. A still greater degree of precision in comparing C and D will be obtained if part of the wire between A and B be a uniform wire laid along a measured scale, and if the point l, to which the galvanometer wire is attached, be made movable along this wire, the resistance of which must be known as compared with the other parts of A and B. Now, if A, B, C and D are as nearly balanced as they can be by the addition and subtraction of units at C, a still more perfect balance (indicated by the absence of deflection in the galvanometer) may be obtained by shifting l a little; then, if its position be observed, giving the exact ratio between A and B, the exact value of D can be found in terms of the unit used at C by a simple-rule of-three-sum. In fact, every change that the rule of three is susceptible of can be worked out effectually by the above arrangement, and measurements can be made without an error of one part in 100,000. Experiments were shown illustrating the above statements. It will now be seen that we have the means of comparing the resistance of wires very accurately, and of comparing all wires with a common unit; but it is also convenient to be able to calculate beforehand what the resistance of a given wire will or ought to be, and for this purpose it will be sufficient to know the resistance of some one wire of known dimensions of each material. The resistance of all other wires of that material can then be simply calculated, since that resistance is directly proportional to the length, and inversely proportional to the section, of the wire. Table IX. is a table of "specific resistances," defined in various ways. The first column contains the numbers which will probably be found most useful. The following is an example of its use: Let it be required to know the resistance at 0° of a conductor of pure hard copper, weighing four hundred pounds per knot. This is equivalent to four hundred and sixty grains per foot. The resistance of a wire weighing one grain per foot is 0·2106; therefore, the resistance of a foot of a wire weighing four hundred and sixty grains will be $\frac{0{\cdot}2106}{460}$,

but the resistance of one knot will be 6087 times that of one foot; hence the resistance required will be $\frac{6087 \times 0{\cdot}2106}{460} = 2{\cdot}79$ units. If

TABLE IX.—*Specific resistance in B A units of metals and alloys at 0° C., from Dr. Matthiessen's experiments.*

Name of metals.	Resistance of a wire one foot long, weighing one grain.	Resistance of a wire one metre long, weighing one gramme.	Resistance of a wire one foot long, $\frac{1}{1000}$th inch in diameter.	Resistance of a wire one metre long, one millimetre in diameter.	Approximate per centage of variation in resistance per degree of temperature at 20°.
Silver annealed.........	0·2214	0·1544	9·936	0·01937	0·377
" hard drawn....	0·2421	0·1689	9·151	0·02103	....
Copper annealed.......	0·2064	0·1440	9·718	0·02057	0·388
" hard drawn...	0·2106	0·1469	9·940	0·02104	....
Gold annealed..........	0·5849	0·4080	12·52	0·02650	0·365
" hard drawn......	0·5950	0·4150	12·74	0·02697	....
Aluminium annealed.	0·06822	0·05759	17·72	0·03751	....
Zinc pressed...............	0·5710	0·3983	32·22	0·07244	0·365
Platinum annealed....	3·536	2·464	55·09	0·1166	....
Iron annealed..........	1·2425	0·7522	59·10	0·1251	....
Nickel annealed.........	1·0785	0·8666	75·78	0·1604	....
Tin pressed................	1·317	0·9184	80·36	0·1701	0·365
Lead pressed............	3·236	2·257	119·39	0·2527	0·387
Antimony pressed	3·324	2·3295	216·0	0·4571	0·389
Bismuth pressed.......	5·054	3·525	798·0	1·689	0·354
Mercury liquid.........	18·740	13·071	600·0	1·270	0·072
*Platinum silver, alloy hard or annealed..................	4·243	2·959	148·35	0·3140	0·031
†German silver, hard or annealed....	2·652	1·850	127·32	0·2695	0·044
‡Gold silver alloy, hard or annealed....	2·391	1·668	66·10	0·1399	0·065

the diameter of the wire be given instead of its weight per knot, the calculation is still simpler, and the constant for English measures would be taken from the third column of the table. Thus, the resistance at 0° of a knot of pure hard drawn copper wire 0·1 inch diameter, would be $\frac{6087 \times 9{\cdot}94}{100^2} = 6{\cdot}05$. It will be seen that annealing wires materi-

* The alloy used for B A resistance units, two parts platinum, one part silver by weight.

† The alloy commonly used for resistance coils.

‡ Two parts gold, one part silver by weight.

ally alters their resistance, though it leaves their chemical composition quite unaltered. A rise in temperature increases the resistance of all the metals, and Dr. Matthiessen discovered that for all pure metals the increase of resistance between 0° and 100° C. is sensibly the same

TABLE X.—*Constants, for metals or alloys, by which to calculate the resistance* R *at temperature* t *from the resistance* r *at zero:* $R = r\,(1 + a\,t \pm b\,t^2)$.

	a.		*b.*
* Pure metals	0·003824	+	0·00000126
Mercury	0·0007485	—	0·000000398
German silver	0·0004433	+	0·000000152
Platinum silver	0·00031		....
Gold silver	0·0006999	—	0·000000062

TABLE XI.—*Resistance in* B A *units of wires one foot long, weighing one grain.*

Temperature, Centigrade.	Soft copper.	Hard copper.	German silver.†	Platinum silver.‡
0	0·2064	0·2106	10·61	16·97
5	0·2102	0·2147	10·628	17·00
10	0·2144	0·2188	10·647	17·02
11	0·2153	0·2197	....	....
12	0·2161	0·2205	....	....
13	0·2170	0·2214	....	....
14	0·2178	0·2222	....	....
15	0·2186	0·2231	10·665	17·05
16	0·2194	0·2239	....	....
17	0·2203	0·2248	....	....
18	0·2211	0·2256	....	....
19	0·2220	0 2265	....	....
20	0·2228	0·2272	10·682	17·08
21	0·2237	0·2283	....	....
22	0·2242	0·2288	....	....
23	0·2253	0·2299	....	....
24	0·2262	0·2308	....	....
25	0·2271	0·2317	10·702	17·10
26	0·2279	0·2325	....	....
27	0·2287	0·2334	....	....
28	0·2296	0·2343	....	....
29	0·2305	0·2352	....	....
30	0·2313	0·2360	10·720	17·13
31	0·2322	0·2369	....	....
32	0·2328	0·2375	....	....
33	0·2340	0·2388	....	....
34	0·2348	0·2396	....	....
35	0·2357	0·2405	10·739	17·15
36	0·2365	0·2413	....	....
37	0·2376	0·2424	....	....
38	0·2383	0·2432	....	....
39	0·2391	0·2440	....	....
40	0·2400	0·2449	10·757	17·18

* Approximate or mean formula. † Calculated from specific gravity 8·47.

‡ Calculated from specific gravity 12·0. (Approximate values only.)

except for iron. Table X. gives the formula and constants by which the resistance of any wire between those limits may be calculated. Roughly, all pure metals increase from 0·37 to 0·39 per cent. for each degree of temperature within the limits usually occurring in rooms. Table XI. gives the specific resistance of the more important metals at various temperatures. The resistance of most alloys is very much greater than the mean of the metals composing them. Indeed, a singularly small mixture of a foreign metal reduces the resistance of the pure metals very largely; so much so, that in commerce copper cannot be obtained which is equal, or even nearly equal, to that of pure copper. The figures and constants given in the above tables are only applicable with accuracy to pure metals. In old cables the quality sometimes was very bad; but lately the resistance of cable-copper has usually been only about ten per cent. more than that of pure copper. Table XII. gives the resistance of the copper of various cables at 24° C.,

TABLE XII.—*Resistance per knot and specific resistance in* B A *units of conductors and insulators of various cables at* 24° *C.*

Name of cable.	Resistance per knot of conductor at 24° C.	Specific resistance of foot grain at 24° C.	Resistance per knot of insulator at 24° C., after one minute's electrification.	Specific resistance of insulator, or resistance of one foot cube, at 24° C., after one minute's electrification.
Red Sea	7·94	·2700	28×10^6 to 38×10^6	$0·875 \times 10^{12}$ to $1·187 \times 10^{12}$
Malta-Alexandria, mean	3·49	·2637	115×10^6	$4·06 \times 10^{12}$
Persian Gulf, mean	6·284	·2469	193×10^6	$5·910 \times 10^{12}$
Second Atlantic, mean	4·272	·2421	349×10^6	$11·22 \times 10^{12}$
Hooper's Persian Gulf core, mean	......	......	8000×10^6	245×10^{12}

also the specific resistance at the same temperature. Although alloys cannot be used for cables, owing to their high resistance, they are very useful in the construction of resistance coils, since not only are coils of great resistance made of small bulk by their use, but these coils are much less altered by a change of temperature than if made of simple metals. The tables contain the resistances of the chief alloys now in use, with the co-efficients for temperature corrections. There are many points of great practical importance in measuring the resistance of conductors, which cannot be here fully treated of. Thus, all resistance coils should be wound double, so that the current may pass both ways round the coil equally; this prevents self-induction—a disturb-

ing element. Care must generally be taken in using the Wheatstone balance to connect first the battery at *o*, (Fig. 1,) and then the galvanometer at *p*. The battery must be left connected for the shortest possible time to avoid heating the wires; special precautions must be taken to avoid resistances at connections, which are often considerable. The resistance of the wires composing the balance should not differ too greatly from that to be measured; short wire galvanometers answer best for short wires; long wire galvanometers for long wires;—one cell of large surface generally gives better results than large batteries. The temperature of the wire to be measured, and that of the resistance coils, should be accurately observed. These and many other points could only be fully developed in a treatise on testing. Practically, the copper of a cable is tested before it is used, to ascertain whether its quality is equal to that specified. When a knot of wire is covered it is again tested for resistance, to ensure that the proper quantity and quality of wire has been used; finally, after the cable is covered, the resistance test serves to check the length of the cable in circuit, to ensure that the conductor is at no point interrupted, and that the temperature in the tank is not higher than it should be.

(To be continued.)

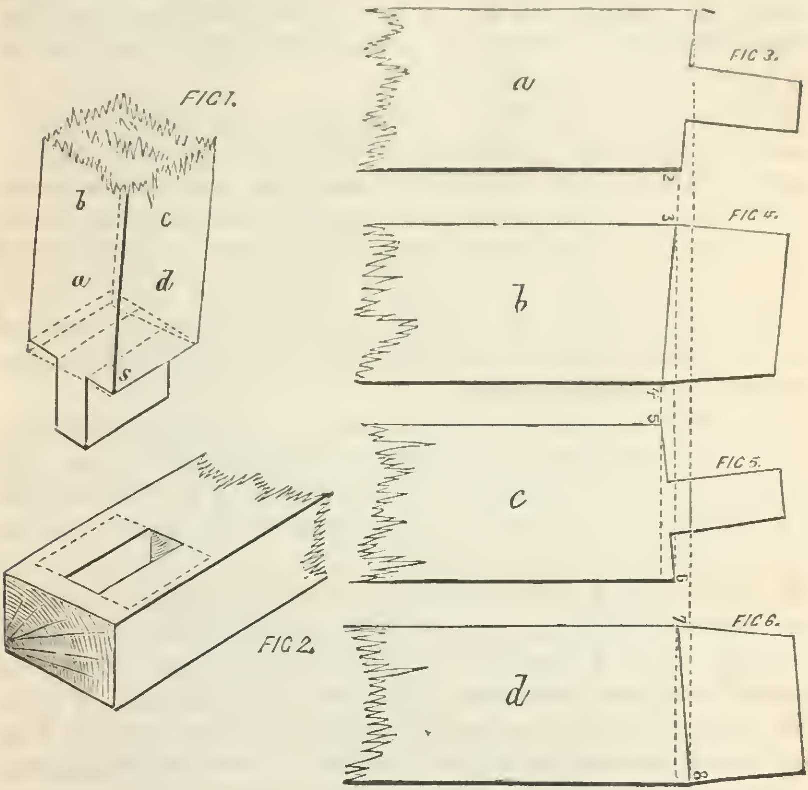
For the Journal of the Franklin Institute.

METHOD OF FRAMING A DOUBLE BATTERED POST.

By Alfred P. Boller, C. E.

Among the many interesting details of framing to be met with in carpentry, that of framing a post into a sill, so that the post will batter in two directions, is perhaps the most difficult, and but few carpenters are able to do it. The accompanying plate gives all lines that are required to scribe out such a piece of work, and can readily be understood. Fig. 1 shows an isometrical view of the foot of a post with its tenon, and Fig. 2 the ordinary mortise in the sill to which it is to be attached. Figs. 3, 4, 5 and 6 represent all four sides of the post, and for convenience of illustration, is drawn to a scale of one-twelfth its real size, the batter being one inch to the foot. The construction is as follows: Starting from the corner one, Fig. 3, (corresponding to the corner S, Fig. 1,) draw 1–2 an inch from the vertical, making the tenon perpendicular to it. This gives the face *a*. The face *b* is formed by projecting 2 to 3, and drawing 3–4 an additional inch from the vertical, and the tenon parallel to this new line. The point 4 is now two inches from 1, and is half-way around the post. Now batter

each of the remaining two faces in a reverse direction, until the point 8 is reached, which coincides with the starting point 1. We have thus traveled around, as it were, each face of the post, and scribed out the shoulders of the tenon.



Report of the Committee on Science and the Arts, constituted by the Franklin Institute, on the Harrison Steam Boiler.

Invented by Joseph Harrison, Jr., Philadelphia, Pa.

The Committee to whom was referred the examination of the "Harrison Boiler," report that, on Tuesday, October 30th, they visited the foundry of Mr. Joseph Harrison, Jr., Philadelphia, and had an opportunity of inspecting the boilers in various stages of manufacture, and of seeing several in operation.

Experiments were tried to prove the strength and durability of the boiler under extraordinarily severe use.

The boilers are of cast iron, formed of a combination of hollow spheres each eight inches diameter externally, and three-eights of an inch thick, connected by curved necks three and a quarter inches diameter. These spheres are held together by wrought iron bolts, and in one direction are cast in sets of two or four, with opposite lateral openings to each sphere, and are called by the inventor two or four-ball units, as the case may be.

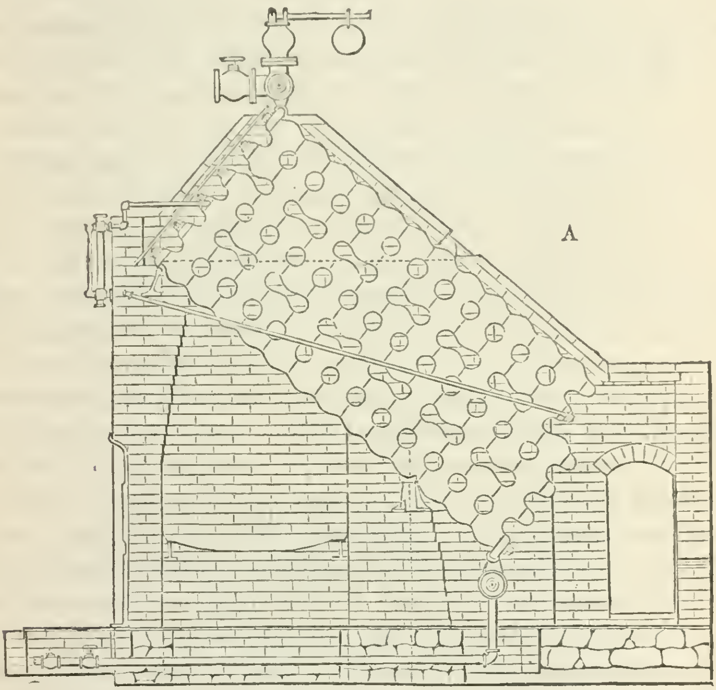
He assumes that the boiler, in its smallest form, may be considered as one of these balls, with its opposite lateral openings closed by caps held in place by bolts. Two balls united by a neck, with caps over the four lateral openings, in the same manner would also make a boiler of a larger size. Four balls so united in one casting, would be a still larger boiler, and that any number of these balls or spheres may be united by bolts passing through them so as to form large boilers, and the strength of the boilers so made will be the strength of the weakest sphere or ball in the structure.

In manufacturing the boiler for ordinary use, a number of these units are generally so arranged as to form sections twelve and thirteen balls long, six balls wide, as shown by the annexed sketch A. These sections are all tested by hydrostatic pressure as high as three hundred pounds per square inch, before being delivered to purchasers. The Committee saw one of these sections subjected to a bursting pressure of water, one sphere bursting when the pressure had reached six hundred pounds per square inch. A second one, tested in the same manner, burst at six hundred and twenty-five pounds. They were shown a section in which one unit had burst at nine hundred pounds per square inch, the damage having been repaired by the insertion of a new unit. The section then stood eleven hundred pounds per square inch before bursting in a new place. The available strength of the section in all cases being the strength of the weakest unit in it, the inventor holds that the boiler is safer than any other in use; in fact, considers it entirely free from any danger of disastrous explosion. To prove which, he had a section equal to six horse-power, similar to the one tested by hydrostatic pressure, and such as he is regularly selling, placed in an extemporary furnace built in a clay-bank, and set the usual manner for a boiler of this kind.

The boiler was filled with water to the regular height, say about two-thirds full, with no outlet or safety-valve of any kind, and sealed up tight, a small tube leading from the upper ball to a high pressure-gauge, placed at a safe distance, about two hundred feet, from the boiler. A fire

was made under and around the boiler, with the fuel of dry pine wood. The wind was very high at the time of the experiment, blowing from the west directly into the furnace, thus fanning the flames to an intense heat.

The gauge soon gave indication of the formation of steam, the pressure steadily increasing up to four hundred and fifty pounds to the square inch.



At this pressure there seemed to be a sudden discharge of steam, as from a small opening. The discharge did not continue for many seconds, and the Committee are not certain that it proceeded from the boiler; there may have been some water discharged from the bank of wet earth into the fire. The pressure then increased at an uniform rate until it had reached the enormous strain of eight hundred and seventy-five pounds per square inch, when a sudden discharge of steam took place, seemingly no greater in volume than might issue from a safety-valve of two and a half inches diameter, or even less; after which the pressure fell to four hundred and fifty pounds, at which it stood when the fire was drawn for examination. While this boiler was being

uncovered for examination, a boiler of about twelve horse-power, consisting of two sections, similar to the ones previously experimented upon, was fired, and steam raised to one hundred and twenty-five pounds pressure. This boiler had no safety-valve, but was provided with a globe-valve of one inch capacity or area, as an escape-valve to regulate the pressure in the boiler. When the Committee examined this boiler at time of firing, it had two full gauges of water. The escape-valve was opened so as to reduce the pressure to one hundred pounds per square inch, and regulated from time to time to keep the pressure uniform at this point. The fire was pushed and no more water injected into the boiler. In due time the lowest gauge-cock gave no indication of water. Soon afterwards a slight leak was observed in one joint of the left-hand section. This closed in a few minutes, and one opened in a similar manner in the right-hand section; this also closed in a short time. No other leaks showed themselves during the experiment. As the water boiled away the soot began to burn off the upper balls of the sections, that is, off those of the upper balls of the lowest row, visible through a peep-door above the fire-door provided for inspection. The boiler then gradually became red-hot, and even when all the water seemed to be exhausted, and the pressure slowly fell, the gauge stood for some minutes at thirty pounds, as if from the vaporization of some water in the lower courses of the sections, showing that in this red-hot condition the boiler was tight enough to hold pressure. After the fire had been drawn, and the boiler cooled, the bolts holding the units together were found to be loose, as if stretched by the unusual heating of the cast iron surrounding them. During the time of the experiment with low water, the escape-cock was many times closed to increase the pressure, then opened quickly to reduce it to the one hundred pound standard, but with no deleterious result. When the gauge stood at thirty pounds, all of the boiler visible from the peep-door and fire-doors, down to the bridge-wall of the furnace, was at a bright red heat. This was unmistakable, as when the fire was drawn, the boiler was hot enough to ignite wood held against it.

November 13*th*, 1866.—At four o'clock, P.M., the Committee met at the factory. J. Agnew and J. C. Cresson, present. They examined the boilers tested at the former meeting. The boiler which had been subjected to its own steam-pressure of eight hundred and seventy-five pounds per square inch had been removed to the factory for examination. Mr. Harrison's foreman stated that when the boiler was first dragged from the fire, after its water had been forced out, (as

detailed in the account of the experiment, the three lower bolts were quite slack, but the next morning, when it had become cold, one of them was again tight. The other two were not quite tight, but were then screwed up about one turn of the nuts. The Committee are confirmed in their belief that in this extreme test, the pressure at eight hundred and seventy-five pounds was enough to stretch some of the bolts, that the joints opened as safety-valves, and thus relieved the strain on the boiler.

The boiler which, in former experiments, had had all its water boiled out, and had then been heated to bright redness, was found to be quite sound and fit for use, making steam freely and showing no leak, blowing off at sixty-five pounds by safety-valve. It was somewhat disfigured on its outside by oxidation. Your Committee was informed that it had not been changed or repaired since the trial, but that some of the bolts had been screwed up.

A third boiler of the same size as the above, twelve horse-power, was then tested in the following manner: After being filled with water to the upper water-line, it was fired until pressure was raised to ninety pounds, at which it was blowing-off freely. The water was then all blown out by the blow-off cock, the pressure falling to sixty pounds while blowing-off, at which it stood until steam reached the blow-off pipe, when the pressure fell to zero. It was kept empty for three minutes, with the fire still burning, and was then rapidly filled with cold water, and steam raised to one hundred pounds pressure in thirty minutes, blowing off at one hundred pounds, and was quite sound and tight.

The Committee was informed by one of its members, who was a witness of, and cognizant of, all the facts, that at the establishment of Mr. Wm. Sellers & Co., of this city, a boiler of this kind has been in use for about two years. During some experiments in testing the Giffard Injectors made by that firm, a workman inadvertently loosened a connection to the water supply-pipe, resulting in the pipe blowing full open, discharging the water from the boiler as fast as a two-inch diameter opening would allow, the men in the boiler-room barely escaping with their lives. As soon as all the water had blown off, and access could be had to the boilers, the fires were drawn and cold water run in as fast as possible, and in about thirty minutes, the steam was high enough to run the engine, with no seeming injury to the boilers.

The Committee mention this as an accidental experiment, similar to the one above reported. The same boiler is still in use, and seemingly

as good as when first erected. It is, however, the first one erected in this country from units made in England, and is not so good as those made since then. On Saturday, November 17th, Mr. Harrison repeated an experiment in the presence of a part of the Committee, Messrs. Agnew, Morton and Sellers, which experiment he stated had been tried twice the day before, and once two days previous, all the experiments being with the same boiler. The experiment, as witnessed, was as follows:

The boiler which had been under experiment November 13th was fired up, and steam raised to one hundred and ten pounds. The fire was active,—what might be called a very clear fire,—and in good condition to make steam freely. It had been kept up sufficiently long to thoroughly heat all the furnace walls. Steam was blowing-off freely from the safety-valve. At a given signal the blow-off cock was opened suddenly, blowing off all the water until the pressure had fallen to zero, and neither steam nor water was escaping from the blow-off cock. In fact, it is believed the boiler was entirely dry. The blow-off cock was then closed, and cold water from a well pumped rapidly into the hot boiler, for it was at all times exposed to the active fire. As the water entered the boiler, the pressure as per gauge rose slowly during an interval of about three minutes, when it is supposed the water-level had reached the more heated portion of the boiler above the bridge-wall of the furnace, for the pressure seemed instantly to increase to one hundred and ten pounds, and steam blew freely from the safety-valve.

This pressure and escape of steam continued for some minutes with no variation, when suddenly an escape of steam was evident from the boiler into the furnace, and upon opening the peep-hole door a jet of water was seen issuing from one of the joints. This leak, in less than a minute, suddenly stopped; then, as the water rose in the boiler, a similar sudden leak and sudden stoppage occurred at the next higher joint; again, at a third one, when, by that time, the water was showing itself at the lower gauge-cock soon afterwards at the second one, when the pump was stopped, at which time the pressure stood at one hundred and ten pounds, steam blowing off freely from the safety-valve. The fire was as active as when the experiment began, and the boiler perfectly tight. This experiment, as before remarked, had been repeated three times previous to the one witnessed by the Committee, and Mr. Harrison's account of the previous experiments, given to your Committee, agreed in every respect with the facts as seen by them.

This is as severe a test as any boiler is ever accidentally caused to sustain, and is, in fact, the one most likely to occur from carelessness. It is also testing practically the favorite theory to account for explosions. During the experiments, the employees of Mr. Harrison seemed quite fearless in their manipulation of the boilers, showing a confidence in their safety truly remarkable. With the exception of the single boiler sealed up and submitted to the extreme pressure of eight hundred and seventy-five pounds to the square inch, all the experiments were tried within the building in which the boilers are made, and any explosion would have resulted in serious loss of property if not of life. Had any ordinary wrought iron boiler, made in the simplest form, and of the best material, been submittted to these same tests, it would have probably been destroyed by any one of them. Regarding the liability to accumulation of sedimentary deposit in this kind of boiler, we can only say that it is asserted by those who have used them the longest, that by occasionally blowing out the water under a full head of steam, then allowing the empty boiler to be moderately heated by the hot furnace, filling up with water and rinsing out, the scale becomes detached and rushes out at the blow-off cock.

The Committee have carefully inspected the manner of making these boilers as practiced by Mr. Harrison, and find the greatest care is taken to insure perfection of workmanship; but, at the same time, it is eminently noteworthy that the peculiarities of the boiler, and its mode of manufacture, are such as to enable a high degree of mechanical excellence to be obtained by mechanical devices, apart from the workman's skill. Thus, in the process of casting, taking as an example a four-ball unit, the four eight-inch spheres united by necks three and a quarter inches diameter, internally, have on each ball two opposite lateral openings, three and a quarter inches diameter, thus making in all, eight openings to four balls. The patterns are all of cast iron, parted lengthwise through the centre of the unit, by a plane at right angles to the lateral openings, these serving as supports to the green sand core which is moulded within the pattern itself, and not in a separate core-box, thus insuring absolute uniformity to the thickness of the metal, and offering a more yielding core to the contracting metal than in the case of dry-sand moulding. The lateral necks which are to serve as joints in combining the units into the boiler structure, are faced off by machinery of the most ingenious kind, so arranged as to insure neat accuracy in the surface, the joints on one side having depressions to match projecting tongues on the other,

these tongues serving with the longitudinal bolts to hold the units in position. One of the most thorough descriptions of this kind of boiler is the report of a paper read by Mr. Zera Colburn before the Institute of Mechanical Engineers in 1864, an abstract of which can be found in *Engineering Facts and Figures*, by A. Betts Brown, for 1864. He shows, that although the tensile strength of cast iron is not so great as wrought iron, yet the spherical form of each unit of the boiler gives it an equivalent strength. He says: "The strength of a hollow sphere to resist internal pressure, is exactly twice that of a hollow cylinder of the same diameter, material and thickness, and it can be shown that even a cast iron sphere, seven feet in diameter and seven-sixteenths of an inch thick, is as strong as the shell of a Cornish boiler of the same dimensions." "The plane in which rupture, if it happen at all, will take place in a hollow sphere, is the largest plane that can be drawn through it, and the metal resisting the strain tending to cause rupture is the whole section of metal bounding the plane." "In a hollow cylinder, the area upon which the greatest pressure tending to cause rupture will be exerted, is that represented by the product of the length into the 'diameter of the cylinder.'" The ends of such a cylinder add nothing to the strength of the cylindrical part, in case of a rupture beginning at the cylindrical part.* The spherical form of each part of this boiler is one of its marked advantages, not only so far as strength is concerned, but as enabling a much larger amount of surface to be exposed to the fire than in any form of combined cylinder. To the spherical form with the curved necks, has been ascribed by the inventor the property, which this boiler is asserted as having to cast its scale when emptied of water, as there is no seeming abutment for the arch of the crystallized scale to spring from. The value of cast iron, so far as durability is concerned, has long been conceded. The purer the iron the more readily does it corrode, while the mixture of even a small amount of carbon increases its ability to resist corrosion. Wrought iron water-pipe under ground soon rusts out. Cast iron, even of the same thickness, remains good after many years' use; in fact, is considered practically to suffer no deterioration. Wrought iron in boilers decays internally—the most rapidly where moisture and air both operate, as in the upper side of mud-drums, while they are often eaten

---

* The metal effectively resisting the rupture in the cylinder, being only the length of the cylinder. Thus, by comparison, Mr. Colburn arrives at his conclusion as to the relative strength of the two forms.—(See *Engineering Facts and Figures*, 1864, pages 12 and 13.)

through from the outside by trifling leaks, and the constant trickle of water over the surface. Wrought iron boilers are, according to the experiments of Fairbairn and others, so much weakened by the process of riveting &c., as to suffer a deterioration of about forty per cent. The Harrison boiler is made of pieces of as uniform strength as possible, united in a systematic manner. The uniting the units or pieces into mass does not diminish their strength. In case of accident to any part of the boiler the damaged part may be removed, and instead of being repaired, as is done with other wrought iron boilers, new parts may be substituted, just as bricks may be taken out and new ones replaced in a building. The patching of a damaged wrought iron boiler makes it weaker. The renewal of any part of the Harrison boiler gives it its original strength.

The experiments heretofore described, have been conducted to determine the safety and durability of the boiler under unusual and severe usage, or rather to determine whether any danger can result from submitting this kind of boiler to those circumstances which, in ordinary wrought iron boilers, are thought to result in explosions, or great injury to the boiler.

The Committee are impressed with the great utility of the boiler, as one perfectly safe and free from all danger of explosion even when carelessly used. This recommendation alone, in a humanitarian point of view, must strongly commend it to public favor. During the experiments, its steam-making qualities were favorably noticed, and such boilers in actual use as your Committee have had an opportunity to examine, seem to give satisfaction in point of economy; but in the absence of all experiments in this direction, conducted under their immediate supervision, they do not feel qualified to report in figures as to its steam-making efficiency.

Comparing cast iron plates with wrought iron ones of the same thickness, the transmission of heat is known to be in favor of the former; hence the material, if in a safe form, is better adapted to economical steam-making, than wrought iron. Ordinary boiler plate is seldom less than one-fourth of an inch thick, and more commonly three-eighths, particularly for high pressure. The castings used in the experiments for safety, were not over three-eighths of an inch thick, and in one boiler set up in a form adapting it to marine purposes, some of the units were only three-sixteenths of an inch thick, and were worked successfully at one hundred pounds pressure, driving all the machinery in Mr. Harrison's factory in an efficient manner. The principle of en-

largement of the boiler by addition of units, and the fact that it can be constructed in any shape or style, just as various kinds of buildings are constructed of ordinary bricks, places it in the power of the engineer to adapt it in its form to the requirements of each particular case; so that with the known advantage of the use of cast iron, and the unlimited scope in the arrangement of heat-absorbing surface, coupled with the demonstrated fact of safety, your Committee unhesitatingly approve and heartily recommend it to public favor.

Subcommittee appointed to make the examination: Coleman Sellers, Chairman; John Agnew, John F. Frazer, Henry Morton, J. C. Cresson.

Franklin Institute.

Proceedings of the Stated Monthly Meeting, December 19th, 1866.

THE meeting was called to order with the President, Mr. William Sellers, in the chair.

The minutes of the last meeting were read and approved.

The Board of Managers reported their minutes, and that, at their meeting held on the 19th inst., donations were received from the Royal Astronomical Society and the Society of Arts, London, and from the United States Sanitary Commission. They also reported the Treasurer's annual statement for the year 1866.

The Annual Report of the President of the Institute was then read as follows:

PRESIDENT'S REPORT.

In compliance with the third section of Article XIV. of the By-laws of the Institute, the Board of Managers present the following report concerning the operations of the Institute during the year 1866, and its general condition at the present time.

The very extensive improvements noticed in the last report, and which were at that time approaching completion, have now been entirely finished, and have, during a year's use, shown themselves to be of a very satisfactory character.

The lecture-room, as modified, in accordance with the requirements of modern science and the plans adopted by the Board, has been found

exceedingly convenient, both for the meetings of the Institute and for the various courses of lectures which have been delivered before that body.

In the latter respect, however, it has been found wanting, not in convenience and fitness of arrangement, but in adequacy of accommodation for the large audiences drawn together by that increased interest in the Institute and its objects, which has of late been exhibited in so gratifying a degree. In this respect, indeed, the indications seem to point to the propriety of seeking enlarged accommodations and increased facilities for developing the usefulness of this Institution.

With respect to the Library and Reading-room, the improvements above mentioned and before described have been found of great value, facilitating the use of both, by the members of the Institute and strangers visiting the city, as evidenced by the enlarged occupation of the latter, and reference to the former.

The Library has undergone a general re-arrangement, and cataloguing, now nearly completed, by which its usefulness is decidedly increased, as well as by the addition of many new and valuable works.

The number of members of the Institute has been largely increased during the last year, as will be seen from the following statement:

Total number of members in 1865			1433
Elected in 1866		142	
Stockholders added 1866		20	
		162	
Resignations	50		
Deaths	17—	67—	95
			1528

The account of the Treasurer, which is herewith submitted, also shows a satisfactory condition of the finances, and we may confidently look for an increased prosperity to the Institute, should the co-operation and support it so well deserves from all interested in the Mechanic Arts be continued and enlarged.

Balance in Treasury, January 1st., 1866	$ 1,002 62
Receipts during the year	14,333 14
	$15,335 76
Payments	12,598 01
Leaving a balance in the Treasury	$ 2,737 75

The indebtedness of the Institute is—

Amount of five per cent. loan	$11,600 00
Interest due thereon	3,863 75
Temporary loan	2,500 00
	$17,963 75

The various Standing Committees reported their minutes.

The Special Committee on Experiments in Steam Expansion reported progress.

No report having been made by the Committee on General Totten's letter, with regard to the establishment of a Government Bureau of Mechanical Examination and Experiment, it was, on motion of Frederick Fraley, Esq.,

Resolved, That this Committee be directed to report at the next meeting, being subject to discharge according to Section 3 of Article X. of the By-laws.

The Special Committee appointed to collect materials with relation to the history of the Institute, reported progress.

The paper announced for the evening (On Steam Boilers, by Joseph Harrison, Jr.) was then read. (An abstract of this paper will be found in this *Journal*, beginning with page 131 of the present number.)

At the conclusion of Mr. Harrison's paper, the President expressed to Mr. Harrison the thanks of the Institute; after which the Judges of Election reported the result of the ballot as follows:

Officers, Managers and Auditors of the Franklin Institute, elected January 16th, 1867: President, J. Vaughan Merrick; Vice-Presidents, (for three years,) Coleman Sellers; (for one year,) to fill a vacancy, George Erety; Secretary, Henry Morton; Treasurer, Frederick Fraley; Managers, (for one year,) to fill a vacancy, Robert E. Rogers, M.D.; (for two years,) to fill a vacancy, Robert Briggs; (for three years,) William Sellers, William J. Horstmann, Henry Cartwright, Samuel Hart, B. H. Moore, H. G. Morris, W. B. Bement, E. Y. Townsend; Auditor, James H. Cresson.

The Ex-President, Mr. William Sellers, then inducted to the chair the new President, Mr. J. V. Merrick.

Some remarks on the quadrature of the circle by various new plans were then made by Mr. John May, and a paper on the manufacture of bricks, ancient and modern, was read by Mr. Bond.

It was then moved by Mr. Coleman Sellers, that on account of the lateness of the hour, the reading of the Secretary's Report be dispensed with, which motion was duly carried, and there being no deferred or new business for consideration, the meeting was, on motion, adjourned.

HENRY MORTON, *Resident Secretary*.

A COMPARISON *of some of the Meteorological Phenomena of* DECEMBER, 1866, *with those of* DECEMBER, 1865, *and of the same month for* SIXTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11¼′ W. from Greenwich. By PROF. J. A. KIRKPATRICK, of the Central High School.

	December, 1866.	December, 1865.	December, for 16 years.
Thermometer—Highest—degree	61·00	63·00	71·00
" date	8th.	27th.	2d, '59.
Warmest day—mean	57·00	55·33	62·80
" " date	8th.	4th.	2d, '59.
Lowest—degree	6·00	17·00	4·50
" date	21st.	15th.	19th, '56.
Coldest day—mean	15·33	21·67	11·00
" " date	21st.	15th.	18th, '56.
Mean daily oscillation	12·10	11·23	12·11
" " range	6·83	6·85	6·50
Means at 7 A. M.	31·58	35·34	32·00
" 2 P. M.	37·18	40·82	39·18
" 9 P. M.	34·19	36·95	34·80
" for the month	34·32	37·70	35·32
Barometer—Highest—inches	....	30·424	30·678
" date	....	23d.	18th, '56.
Greatest mean daily pressure	....	30·399	30·611
" " " date	....	23d.	18th, '56.
Lowest—inches	....	29·403	28·946
" date	....	21st.	9th, '55.
Least mean daily pressure	....	29·535	29·175
" " " date	....	1st.	9th, '54.
Mean daily range	....	0·206	0·215
Means at 7 A. M	....	29·945	29·950
" 2 P. M	....	29·899	29·907
" 9 P. M	....	29·946	29·936
" for the month	....	29·930	29·931
Force of Vapor—Greatest—inches	0·472	0·509	0·551
" date	8th.	27th.	2d, '59.
Least—inches	·042	·068	·025
" date	20th.	22d.	18th, '56.
Means at 7 A. M	·152	·177	·146
" 2 P. M	·153	·180	·167
" 9 P. M	·165	·182	·158
" for the month	·157	·180	·157
Relative Humidity—Greatest—per cent	96·0	97·0	100·0
" date	16th.	27th.	Often.
Least—per cent	35·0	33·0	23·0
" date	9th.	5th.	15th, '61.
Means at 7 A. M.	79·4	80·7	77·5
" 2 P. M.	64·5	64·3	65·2
" 9 P. M.	76·9	76·7	75·2
" for the month	73·6	73·9	72·6
Clouds—Number of clear days*	14·	6·	8·8
" cloudy days	17·	25·	22·2
Means of sky covered at 7 A. M	46·4 per ct	74·8 per ct	63·6 per ct
" " " 2 P. M	56·4	61·6	63·2
" " " 9 P. M	42·6	60·0	48·7
" " for the month	48·5	65·5	58·5
Rain and melted snow—Amount—inches	3·522	5·677	3·822
No. of days on which rain or snow fell	9·	12·	10·5
Prevailing Winds—Times in 1000	N78°16′W·351	N68°27′W·239	N63°53′W·273

* Sky one-third or less covered at the hours of observation.

A COMPARISON *of some of the Meteorological Phenomena of the year* 1866, *with those of* 1865, *and of the last* FIFTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11¼′ W. from Greenwich. By J. A. KIRKPATRICK, A. M.

	1866.	1865.	15 years.
Thermometer—Highest—degree	101·00	97·00	101·00
" date	July 17.	July 7.	July 17, '66.
Warmest day—mean	92·33	87·33	92·33
" " date	July 17.	July 28.	July 17, '66.
Lowest—degree	—9·00	3·50	—9·00
" date	Jan. 8.	Feb. 13.	Jan. 8, '66.
Coldest day—mean	2·67	12·00	—1·00
" " date	Jan. 8.	Feb. 13.	Jan. 9, '56.
Mean daily oscillation	13·91	12·40	14·79
" " range	5·80	5·52	5·55
Means at 7 A. M	50·67	52·10	49·98
" 2 P. M	60·02	60·47	59·93
" 9 P. M	54·00	54·74	53·35
" for the year	54·90	55·77	54·42
*Barometer—Highest—inches	30·757	30·424	30·757
" date	Jan. 8.	Dec. 23.	Jan. 8, '66.
Greatest mean daily pressure	30·665	30·399	30·665
" " " date	Jan. 8.	Dec. 23.	Jan. 8, '66.
Lowest—inches	28·820	29·141	28·820
" date	April 23.	Jan. 7.	Ap'l 23, '66.
Least mean daily pressure	29·051	29·226	28·958
" " " date	April 23.	Oct. 19.	Ap'l 21, '52.
Mean daily range	0·150	0·152	0·155
Means at 7 A. M	29·860	29·852	29·877
" 2 P. M	29·809	29·811	29·836
" 9 P. M	29·842	29·846	29·864
" for the year	29·837	29·836	29·859
Force of Vapor—Greatest—inches	0·980	0·917	1·059
" date	July 17.	July 25.	June 30, '55.
Least—inches	·024	·044	·013
" date	Jan. 8.	Feb. 13.	Feb. 6, '55.
Means at 7 A. M	·331	·348	·325
" 2 P. M	·342	·361	·340
" 9 P. M	·361	·364	·346
" for the year	·345	·358	·337
Relative Humidity—Greatest—per cent	100·0	100·0	100·0
" date	Jan. 15.	Feb. 23.	Often.
Least—per cent	18·0	23·0	13·0
" date	April 29.	April 24.	Ap'l 13, '52.
Means at 7 A. M	74·9	73·9	75·5
" 2 P. M	56.3	57·7	57·1
" 9 P. M	72·8	70·9	72·0
" for the year	68·0	67·5	68·2
Clouds—Number of clear days†	122·	101·	109·
" cloudy days	243·	264·	256·
Means of sky covered at 7 A. M	56·9 per ct	62·3 per ct	59·9 per ct
" " " 2 P. M	59·8	62·7	60·8
" " " 9 P. M	47·5	45·9	45·9
" " " for the year	54·7	57·0	55·6
Rain and melted snow—Amount—inches	43·573	53·637	45·858
No. of days on which rain or snow fell	116·	119·	127.
Prevailing Winds—Times in 1000	N 88°15′ W ·315	S 89°52′ W ·213	N 77°49′ W ·208

* The barometrical averages for December, for fifteen years, being taken as the averages for December, 1866.

† Sky one-third or less covered at the hours of observation.

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

Vol. LIII.] MARCH, 1867. [No. 3.

EDITORIAL.

The interest of the manufacturing part of our community is at this time strongly excited by the steps which are being taken, in reference to steam-boiler inspection, by our local government. Nor is this interest, indeed, confined to a single class, since all who inhabit our city, must feel that the question involved, may at any moment become a personal and vital one to themselves, should unsafe boilers be allowed to run unchallenged until their unsound condition is revealed by some fatal catastrophe.

The committee who have it in charge to frame an ordinance which shall regulate the entire department of inspection and its operations, have called upon mechanical engineers and men of science, to aid them with their advice, and have by this time accumulated no small mass of wisdom and unwisdom, from various quarters.

The electrical theory has been broached and advocated, and a lightning-rod prescribed as a panacea. The theory of explosive gases has found an advocate and expounder, and the committee have been taught how to apply an antidote. All forms of indicators and tell-tales, have been commended by some and denounced by others;

hydraulic tests have shared the same fate, and on the whole, the most prominent idea in the minds of the Law Committee by this time, we suspect, must be, "who shall decide where doctors disagree?"

Under these conditions, we think that all will approve the course of the Franklin Institute, in arranging to hold special meetings for the purpose of discussing the proposed city ordinance, and then; when the best wisdom of its eminent and respected engineers shall have been by this means combined, digested and consolidated, to submit the same, with all the weight which such a combination must possess, to the consideration, of the Law Committee and of Councils.

Such services as those thus proposed, come peculiarly well from the Institute, for it was this body which in 1835–36 furnished to the Senate of the United States the draft of a bill which was duly enacted, and became the law governing the inspection of the boilers and engines of vessels propelled by steam.

The investigations which were made at that time by the Institute, and which were embodied in the Reports on Steam-boiler Explosions and on the Strength of the Material for Steam-boilers, (published in the volumes of this *Journal* for the years 1836 and 1837,) are widely known, and may be studied with advantage at the present time.

A committee of the Institute is moreover, now engaged, in concert with the officers appointed by the government, and a committee of the American Academy, in the prosecution of elaborate and important experiments on steam-expansion.

In connection with the same subject, we would call attention to the article on Overheated Steam-boilers, published in our issue of last month, and to the following quotation from an abstract of the report presented by the Chief Engineer of the Manchester Boiler Association, at a late meeting, which we find in the *London Mechanics' Magazine* for January 4th, just received. This is merely one, among a thousand daily recurring evidences of the necessity which exists for thorough inspection of steam-boilers, and we quote it, not because of its special individual importance, but because it shows how, at this time, explosions are actually being prevented by proper care.

"The case of fracture above alluded to is, perhaps, one more pregnant with danger than any before met with in the inspections of this association. It was found in one of three boilers, all of which were about seven feet six inches in diameter, connected together, and worked at a pressure of nearly sixty pounds on the square inch. The defect consisted of a crack, which ran from rivet-hole to rivet-

hole of the inner overlap of the plate, at a longitudinal seam of rivets near to the top of the boiler, the depth of the crack being half the thickness of the plate, while it extended to within a few inches of its entire width. Had it developed, as many cracks do, so as to lead to the rupture of the plate, the most serious consequences must have resulted. Not only would the shell of the boiler in question have been torn to pieces, but the adjoining boilers thrown from their seat, and possibly exploded from the shock, as has been found to be the case under similar circumstances. The boiler was but about three years old, so that it shows that 'entire' examinations are important even for new boilers."

In connection with the experiments and reports of the Franklin Institute noticed above, we cannot forget the great services rendered in the development of both, by Prof. Alexander Dallas Bache, whose loss the Institute and his country at large, have now reason to deplore. As will be seen from the Report of Proceedings on page 209, the decease of this eminent man was announced at the last meeting of the Institute, and appropriate resolutions were at that time duly proposed and adopted. All who on that occasion spoke from personal recollection of Prof. Bache, united in their praise of his generous appreciation of worth and ability, his indefatigable energy in the prosecution of research, his remarkable powers of organization and judicious selection of agents, and his genial, sympathetic and amiable character in all social and professional relations.

PRACTICAL PHOTO-LITHOGRAPHY.

Our readers doubtless remember the very interesting paper read before the Franklin Institute by Mr. J. W. Osborne, on the subject of Photo-Lithography, and his peculiar process for reproducing existing originals. We have recently seen some very fine specimens made by Mr. Osborne, in this country, and we believe he has now nearly completed his arrangements for conducting the process on a large scale, a company having been formed in New York for that purpose.

In this process the original drawing, engraving, pen-sketch or the like, is copied by the camera, and reduced or enlarged as may be required. From the negative so made, he prepares a peculiar print

upon paper, capable of being transferred to the lithographic stone. The integrity of the original is thus insured to the copy. Engineers will find this method of illustrating their works of great value, as fac-similes of most valuable drawings can be made with absolute correctness, and with no injury to the original. We may be able at no very distant day to show in these pages, specimens of Mr. Osborne's skill; for we shall certainly avail ourselves of the advantages of his process, at the earliest opportunity. . . .

UNION PACIFIC RAILROAD.

We have seen with pleasure a series of stereoscopic views made by Mr. John Carbutt, of 131 Lake Street, Chicago, Ill., illustrating the excursion to the 100th Meridian, October, 1866. Apart from being remarkably well executed pictures, they are of especial interest as a record of the progres of this great engineering work. Following the series, we can land with the excursionists at Omaha, and with them on their western journey visit the indian camps, and see the Pawnee indians, with a back-ground of palace cars. All the shops belonging to the road can be seen, and the numbers 222 and 223 show Burnetizing works at Omaha. After seeing the group standing at the 100th meridian, we can next, in 209, see the workmen laying the rails, (two miles a day;) and finally, in 208, one looks westward over a level country. Standing beyond the last rail we can see the sleepers in place, off, far off into the distance, and we can feel that it is "thus westward the monarch capital makes its way." . . .

THE CHICAGO LAKE TUNNEL.

We have likewise received from Mr. F. Carbutt, of Chicago, two stereoscopic pictures of the famous tunnel. One is taken in the interior at the shore-end, and shows the vault for some distance with a car (such as was used for removal of earth, and carriage of building material) standing on the tram-way. Magnesium light has evidently been employed to secure this picture. The other view shows the "crib" used for the lake-end of the tunnel, as it appeared before launching. Numerous figures, clustered like bees upon the structure, give a vivid idea of its enormous size. We see also that this "crib" is square, and not eight-sided, as stated some time since by one of our contemporaries.

HOW TO SELECT INDIAN INK.

INDIAN ink, or Chinese ink, as it is sometimes called, when wanted for the purpose of mechanical drawings, is best tested in the following manner:

Rub in a porcelain paint-dish, as usual, to the required consistency. Then, with it, rule a number of lines on a piece of drawing-paper, making the lines of various thicknesses, corresponding with the fine and shade lines of a drawing. When the lines have dried, brush over them with water freely. Good ink will stand the washing and the lines will keep sharp and clear; poor ink will run or spread sideways as soon as the paper is wetted. The best ink comes from Japan. It is rather hard to rub, but to overcome this difficulty use a piece of slate, say one and a half inch wide and four inches long, resting one end in the paint-dish in which some water has been poured about four or five drops. Then rubbing the ink on the slate, close to the water, and washing it down into the water, it will soon obtain the required blackness.

JAM-NUTS AND THEIR OFFICE.

THE remarks of council and questions put to witnesses at the late trial, arising from the loosening of a nut and consequent fall of a heavy piece of machinery, drew our attention to the general want of correct ideas on the subject specified in the above title, and we believe a few words of explanation will not be misplaced.

The office of a jam-nut is, first, to secure in place and take up the play in adjusting screws which require to be loosely fitted so as to turn readily, and when set require fastening. Second, to keep in place a nut on a screw, having no other bearing to secure its position, as in the stud or standing bolts of the stuffing-boxes for valve-rod, piston-rod, &c. But where a nut is already screwed down to a bearing, and jammed against a nut-bearing, the addition of a jam-nut is entirely useless, and serves only to transfer the binding strain from the first nut to the second one, and if there is any play in the threads of the screw or nut, the first one will be relieved of its pressure and will act as a washer only between the last nut and the bearing. In the case alluded to,

an eye-bolt at the top of the cage of a hoisting machine, to which eye-bolt the hoisting machine was attached, was secured by a nut which drew it down hard on to a shoulder, but after many years' use the nut came off and the cage fell down the hatchway. The builders of the machinery state that they had screwed up the nut and then riveted the bolt over the nut. The nut, however, may have been removed at some time to do some repairs and been replaced without that precaution. And various theories were advanced to account for its working off—all mere surmises, of course. If the twisting and untwisting of the chain gradually unscrewed the nut, a better plan than resorting to jam-nut, under the already firmly secured nut, would have been to have made a part of the nut, where it passed through the metal square, and fitted it into a square hole. The chain could not in that case have turned the eye-bolt. . . .

Engineering Items.

Compressed wood-packing for surface condensers.—On the occasion of a late visit to the Novelty Works in New York, we saw, among other ingenious and interesting appliances, the articles above-mentioned, in course of manufacture. In surface-condensers, where the condensing-water passes through small tubes, it is essential that these should be so held in the tube-plate, as to allow lateral motion without loss of tightness in the joint. To gain this end, a machine has been made by which wood of the character of seasoned, straight-grained white pine, being shaped into short tubes, these may be compressed to two-thirds their original thickness.

This is accomplished by threading the tubes on a conical spindle, which carries them into a conical die, by which means the walls of the tube are compressed as required. These compressed cylinders are then placed on the ends of the tubes in the holes of the tube-plate, which are sufficiently large to receive them readily. On the application of moisture, however, the wood-fibre swells so as to make a perfectly tight joint, which will, however, allow the necessary lateral movement to take place.

A Lenoir gas engine is now in operation in this city, at the establishment of H. A. Fisher, 415 Arch Street, where it has been put up by Messrs. Canby & Brother, who are the agents for this apparatus in Philadelphia.

The Hicks engine.—We have received from several sources good accounts as to the performance of this motor, and propose at an early date to give our readers a full illustrated description of its details in its present improved and efficient form. At present we merely premise that in this form of engine, all valve-gearing, eccentrics, links for reversing, boxes and many other parts are dispensed with, to the great economy of first cost, maintenance and space occupied. Two cylinders and pistons, placed side by side, are so arranged that each acts as a valve for its companion. The whole plan is entirely original, very ingenious, and seems to prove practically efficient. One of these engines has for some time been employed in the establishment of Mr. Joseph Harrison.

A road locomotive built by M. Schinids is in successful operation in the vicinity of Zurich, as is stated in a Lausanne paper.

Wire making, by a continuous process of rolling, is now conducted on a large scale by Messrs. Johnson & Nephew at Manchester. The iron, in blooms of one hundred and two pounds, is heated in a Siemen's gas furnace, from which it passes directly through a series of rollers which are geared so as to give an increasing velocity proportional to the elongation of the bar, and by this means one end is being wound on a reel, finished, while the other is still in the furnace.

Steel-headed rail.—A compound steel and iron rail has been shown to us which was manufactured at the Wyandotte Rolling Mills (from Bessemer steel, and iron, manufactured at the same place,) which is produced by a peculiar mode of piling, devised by Mr. S. L. Potter, superintendent of the above works. The plan employed consists in so placing in the furnace a rail pile, containing a bar of Bessemer steel five by four inches in section, that the steel receives heat through the iron, and thus the true welding heat of both iron and steel is reached at the same time, by which means a very perfect weld is secured. These rails cost but forty per cent. more than the ordinary iron ones, and it is said will outwear those entirely of steel, especially when exposed to severe cold, while the cost of these last is double that of the usual iron rail. We subjoin a record of some tests lately applied to these in comparison with a Dortized rail.

Record of the comparative test of a Dortized rail with a steel-headed rail made at the Wyandotte Rolling Mill, Michigan, (S. L. Potter's patent.) Test made by Wm. M. Lyon, Esq., of the Sligo Iron Works, Pittsburgh.

A weight of sixteen hundred pounds was allowed to fall four feet upon a piece of Dortized rail five feet long; it broke at the first blow.

A piece of the steel-headed rail made at Wyandotte, was then put under the drop, and subjected to four blows as follows: For the first blow, the weight was raised five feet; for the second, ten feet. The rail was then turned over, and received the third blow with a fall of fifteen feet, and the fourth blow, with a fall of twenty feet, bent the rail almost double. The rail was then taken to the steam hammer whose weight was eight thousand eight hundred pounds, and received ten or twelve blows. When the bar was nearly straightened out, it broke, but the iron and steel remained perfectly welded together. One of these pieces was then subjected to one hundred blows from the eight thousand eight hundred pound hammer on the head of the rail, as follows: Fifty blows at two feet fall, and fifty at three feet fall. This crushed the rail without breaking the weld of the iron and steel. The above tests were made March 1st.

The boring of large cylinders is conducted at the Novelty Works in a very simple and ingenious manner. All framing (which in this case would be very bulky, costly and cumbrous) is dispensed with, and the cylinder to be bored, is pressed into service, as frame and support for the tool which is to finish it. The cylinder, in fact, being firmly secured in an upright position, on a bed-plate which has a central bearing for the boring shaft, this last is lowered into it, and secured by proper adjustments to the upper edge, whereupon the *boring machine* is complete.

Improvement in pumps.—At the last meeting of the Institute, there was exhibited an improved form of pump, invented by Mr. Robert Cornelius, and very efficient in dealing with mingled compressible and incompressible fluids, such as the water and gas found in oil wells. The prominent feature in this plan is, that when the piston reaches the upper end of its stroke, it opens or exposes a communication between the spaces above and below it. If, therefore, gas has been drawn in from below, and there is water in the pipe above, the two exchange places by reason of their different densities, and the gas is driven out instead of cushioning under the piston and rendering its motion ineffective, as is otherwise the case. These pumps have been of great service in the oil wells, but their range of application is by no means restricted to this field.

The fouling of mercury gauges may be prevented by introducing a few drops of glycerine in the tube, on top of the mercury. The glycerine by its superior adhesion, lubricates the glass and keeps the mercury from contact with it.

Civil and Mechanical Engineering.

(Continued from page 107.)

THE NEW YORK "CENTRAL PARK."

By William H. Grant, Superintending Engineer.

To the public, or rather to what we are fain to consider a small and ungracious part of it, we would simply say, do not do yourselves injustice by failing to open your eyes to the progress around you, to the advances, capabilities and true merits of the profession. In whatever department or function that pertains to it, judge of it by the rule that applies to all professions and vocations, without antiquated prejudices; investigate its failures and shortcomings, if such run more in your mind than its successes, be well assured of their causes, and determine whether they are inherent or hereditary, or accidental and exceptional. If you have need of a physician, you look for one who has had opportunities of perfecting himself in the healing art, and has availed himself of them in theory and practice;—so with the engineer; inquire into the groundwork upon which he builds, see whether he has employed the means that have given success to others; make yourselves somewhat acquainted with his profession, (you have not neglected this in the case of the physician;) what are its legitimate duties and scope; is it probable the engineer will succeed better in doing what his education and practice have fitted him to do than another person who has not had such education and practice; has he succeeded or failed in what he has attempted to do, on whatever scale it may be? &c. By this sensible mode of reasoning, which you are doubtless accustomed to in ordinary affairs, you will be able to arrive at a safe and practical conclusion.

The ancient Romans were the most notable road-makers of whom we have any account. They made their roads on a liberal scale, both as to mode and extent, and with unstinted labor and cost, and, considering the main object they seem to have had in view—indestructibility rather than convenience,—they were made with great skill. Their plan was copied from the most indestructible form of nature—the solid rock, and with their imperial ideas and imperial power, it was carried out by following the closest imitation practicable. Rocks

were detached from the quarry in masses that could be transported, hewn into proper shape and replaced together closely joined, to form the superstructure of the road, a foundation having been previously prepared, with great pains, to receive and support the material. The rigid and unyielding surface was made sufficiently smooth for use, and the Roman ideal was attained of a work that was imperishable.

Samples that are still extant show how thorough was the workmanship, and how well the builders understood their art; the broad blocks of stone show evidence of long service in the groove-marks of carriage wheels that passed over them two thousand years ago, but in other respects no change has apparently taken place since the work was constructed. One peculiarity of the Roman roads, besides their solidity, was their general straightness, no ordinary obstacle being permitted to turn them from their direction and cause sinuosities. Ascents, descents and declivities, far more objectionable, were secondary to this principle. "This has been attributed to an imperfect knowledge of mechanics, for the Romans do not appear to have been acquainted with the movable joint in wheel carriages. The carriage body rested solidly upon the axles, which, in four-wheeled vehicles, were rigidly parallel with each other. Being unable readily to turn a bend in the road, it has been concluded that for this reason all their great highways were constructed in as straight lines as possible."*

No improvement appears to have been made upon the Roman plan until within the last one or two hundred years; the art seems to have retrograded even, rather than to have stood still, for a long time after the Roman era. The progress was extremely slow when it commenced, the principal advances being found almost within the present century. It has been said by a modern writer, that the roads of a country or a community are a correct index of the degree of civilization prevailing with the people, and this idea is well illustrated in recurring to the long interval in the past during which no progress was made in the art of road-making.

In England, as late as the reign of Queen Elizabeth, the state of the roads was such that traveling was done throughout the kingdom principally on horseback, by horse-litters and on foot. Coaches are said to have been first introduced into England during that reign. The mode of making roads, up to that time, was but a poor imitation of the old Roman mode. The remains of the old Roman colonial works still existed in many places, and were probably the best portions

---

* Smiles—*Lives of the Engineers.*

of the roads in use. It had become so difficult to maintain the more modern roads that they were, from time to time, abandoned for new tracks that were opened through fields and across lots, (as is the case sometimes in this country, with roads that are temporarily obstructed by snow in winter.) Roads that had long been in use were, in some places, so worn down into the soil, by neglect and the action of rains, as to form trenches or chasms thirty to forty feet deep, which gave rise to local names, as Holloway, and the like. The streets of London were no better than the roads of the country, a filthy stream being permitted to flow through a roughly paved gutter in the middle of the street, improved carriage ways and flagged sidewalks, as now in use, being then unknown. The transportation of the country was done by pack-horses, with panniers, going in droves, in double or single file, clambering over all sorts of ground that would be considered, at this day, impassable. Notwithstanding these difficulties, the introduction of an improved class of roads and stage-coaches met with much popular opposition. Long after the introduction of stage-coaches the roads continued to be so bad as to nearly prohibit their use. A writer of the time, who had made a journey to London by coach, says: "This traval hath soe indisposed me yt I am resolved never to ride up againe in ye coatch." Coach traveling was not only a great hardship, but was extremely dangerous, from the numbers of serious accidents and misadventures that were reported to have occurred. When these things are remembered, it is not to be wondered at that Doctor Johnson was wont to extol the pleasures of a drive, with a spirited horse and an agreeable companion over a fine road, as among the greatest enjoyments of life, when such a —— exhilirating kind of exercise became safe and practicable. The Doctor had been obliged to make his wedding tour on horseback.

It may be noted, that among the objections that were urged by the opponents of stage-coaches and superior roads, was that which arose from a fear of apoplexy, caused by the "incredible speed" of six or eight miles an hour; a number of cases were referred to as having been produced by this "too great rapidity of motion." The journey from Glasgow to London was made, in 1774, by a "flying coach," in the space of two weeks.

Arthur Young says, at a later date, of a road that he had traveled, "I know not, in the whole range of language, terms sufficiently expressive to describe this infernal road. Let me most seriously caution all travelers who may accidentally propose to travel this terrible

country, to avoid it as they would the devil; for a thousand to one they break their necks or their limbs by overthrows or breakings-down. They will here meet with ruts, which I actually measured, four feet deep, and floating with mud, only from a wet summer. What, therefore, must it be after a winter? The only mending it receives is tumbling in some loose stones, which serve no other purpose than jolting a carriage in the most intolerable manner."

Sidney Smith, at a considerably later date, says, characteristically, that "Before the age of stone-breaking, MacAdam, and of railways, it took him nine hours in traveling the forty miles between Taunton and Bath, during which he suffered between ten and twelve thousand severe contusions, whilst his clothes were rubbed to pieces by being jolted about in the stage-coach basket, which was without springs." "Whatever miseries I suffered," he adds, "there was no post to whisk my complaints, for a single penny, to the remotest corners of the empire; and yet, in spite of all these privations, I lived on quietly, and am now ashamed that I was not more discontented, and utterly surprised that all these changes and inventions did not occur two centuries ago."

These examples of the condition of the English roads are taken from the work before referred to, by an English writer. They will suffice to show the great need of a higher civilization—if roads are taken as the test—than existed in one of the most advanced states of Europe up to the beginning of the present century.

The same writer gives numerous instances of the state of society, that very much strengthen the idea of an intimate relationship between superior roads and superior intelligence and refinement.

It would be unjust to omit a reference to his subsequent interesting description of the progress and improvements that followed, after this period, in English road-making. The prejudices against the innovations of stage-coaches and other vehicles, and roads adapted to their use, gradually wore away, and with the growing desire and necessity for improvement, the work at length was taken hold of in earnest, and put in the hands of a class of men who were equal to the task demanded. The fullness of time had in fact arrived, when a new era was about to be inaugurated, which was not only to make advances upon the old Roman ideas of road-making, but was to renovate, in a more enlarged sense, the ways of the world; perfecting old arts and developing new ones; enlarging the scope of human thought and action, and expanding the field of human enterprise to an extent never

before dreamed of. The next seventy-five years was to represent, in progress, many preceding centuries. It was thought singular, as far back as 1768, that the engineer, Smeaton, should give his attention to the subject of road-making, as, from the low state of the art, it was considered a condescension, and derogatory to an engineer to devote his time to the business. But this prejudice was soon to pass away. The successors of Smeaton—Brindley, Rennie, Telford and others, most distinguished in the profession—entered upon the duties, in the employ of the government and of incorporated bodies, and brought their highest skill and qualifications into the service. Between 1784 and 1792, three hundred acts of Parliament were passed, authorizing the construction of roads and bridges, and within the space of a few years these engineers surveyed and executed a well-planned system of roads and bridges over several parts of the kingdom. John Rennie, a Scotch engineer, was among the most prominent in the construction of bridges. Among his works of this kind are the Waterloo, Southwark and New London bridges over the Thames, besides many others, in England and Scotland. The New London bridge was designed by him, but completed by his son, Sir John Rennie. For his success in the design and construction of Waterloo bridge in particular, the elder Rennie was offered the honor of knighthood, but declined it. He was the first to adopt the method of breaking up stones into small pieces, to form the surface of roads, which came into extensive use afterwards under the general name of MacAdam roads. He seems to have claimed no special merit for the invention, and the public were misled into awarding the credit to MacAdam, who did not make such roads until several years later. It may be remarked here, also, that Rennie was the inventor of hollow walls, as made use of in large structures of masonry to admit of greater breadth of foundation with less weight, which was subsequently appropriated by another person, (not an engineer,) and the invention patented by him.

In 1803, Telford—also a Scotch engineer—undertook, in the employ of the English government, the survey and construction of nine hundred and twenty miles of roads in Scotland, and in connection with this work, he built, it is said, no less than twelve hundred bridges, many of them large and costly, and they are still among the finest specimens of bridge architecture extant. He was employed at this about twenty years. So extensive and successful were Telford's works of this kind, that he was humorously designated by his friend—the poet Southey—as "Pontifex Maximus." He continued, later, the

construction of roads (upon a superior plan specially designed by himself, which will be described hereafter, and which has since appropriately gone by his name) in England and Wales, until the general progress and spirit of enterprise which had been engendered in the direction of common roads was abated by the construction of canals, and the incipient advances of railways. His greatest work, as an engineering achievement, is probably the suspension bridge over the Straits of Menai, although his roads, harbors and canals were of greater general utility.

England is indebted to no man more than to Thomas Telford for her material prosperity growing out of the multiplicity of public improvements that he executed. The list of the works that he planned and carried out, through a long and active life, would fill many pages. The engineering profession has had no more able exponent His example and works afford a highly profitable study to the young engineer. He was self-made, rising from humble origin, and encountering many obstacles in early life. It is proper to add, that he was honored and appreciated by his government and people, and finally found a resting place in Westminster Abbey.

Telford remarks upon the astonishing effects of the early improvement of the roads of the country upon the customs, manners and industry of the people. "By these improvements," he says, "the moral habits of the great masses of the working classes are changed." "I consider these improvements among the greatest blessings ever conferred on any country." "It has been the means of advancing the country at least a century."

Since his time it has not been held as derogatory to engineers to give their attention to road-making, nor has it been found that the art was unworthy of some of the best efforts and appliances of engineering skill. A great deal of time has accordingly been devoted of late years to the investigation of the subject, and numerous modes and expedients, together with a great variety of materials, have been resorted to for the purpose of improving or economizing the construction of roads, and much ingenuity and ability have been expended and treatises written upon them. It will not be practicable to cite here these examples. Such hints and ideas as have been culled from them and found available and advantageous, have been embodied in the roads of the Park.

There is no doubt that great improvements are still to be made in road-making—in the discovery, perhaps, of new materials, and in dif-

ferent modes of treatment—to produce more agreeable adaptations of the surface of roads, and possibly greater economy and facilities of construction, but in the various plans that have hitherto been brought into public notice there is nothing to indicate that such improvements are likely to occur immediately, or, at least, to be of such a nature as to supersede the prevailing practices. The safest course, is believed to be, to adhere to plain general principles of construction that have been well demonstrated, and to employ the usual materials (of the best available quality), such as seem to be naturally provided for the purpose, to perfect the mode of treatment and details in all practicable ways, *and to perform the work in a thorough manner.*

The Roman idea of an indestructible road is impracticable; a road that will endure even more than a very few years, it is inexpedient to attempt to make at the present day; for such a road, if it could meet the conditions of economy, would not be likely to meet the conditions —which are quite as absolute—of ease, convenience and safety. The best that can be done, in the way of endurance, is to prepare a foundation that will remain intact when the superficial material wears away, and that will permit the renewal of that material without disturbance or decay. The efforts that have been made to construct city pavements that would resist the destructive forces and ceaseless abrasion they are subjected to, and obviate the necessity for almost constant repairs, have generally failed. The Russ pavement, cast iron pavement, and other forms that have been tried in the city of New York, are instances of this kind. The Russ pavement, composed of large blocks of stone, is an imperfect repetition of the old Roman road. The present method of paving with small cubes of stone, (called the trap block pavement,) if done on a suitably prepared foundation, seems to be about as well adapted to all the conditions of the problem—as regards city streets and great thoroughfares—as can reasonably be expected for some time to come. It is not easy to see how this method could be improved (though it doubtless will be) if carried out thoroughly and faithfully. The materials are abundant, accessible and—as to the stone, from the Palisades—of the best quality, and inexhaustible. The foundation *can be, and should be,* prepared in the best manner, so as to give a firm and equable support to the stones, and obviate caving in and disruptions, and of a sufficiently permanent character to admit of the renewal of the stones without breaking it up. The size of the stones is about a practical medium, sufficiently large to prevent crushing, and small enough to be spanned by a horse's foot,

in such a way that one or more of the points of the shoe, when put down, will strike into, or very near, a surrounding crevice, to prevent slipping. The bottoms of the stones have breadth enough, when properly squared, to give them a good bearing on the foundation material, and the upper surface is as even and regular as is compatible with the mode of construction—not as smooth (or as dangerous) as the Russ pavement, nor as rough as the cobble-stone pavement. It is not adapted to pleasant or comfortable driving, and therefore not suitable for a park or private grounds. For these purposes, a less expensive form of road is preferable.

In closing this chapter, it will not be amiss to add a remark upon our common roads in the country. In reviewing the condition of the English roads, in the last century and the forepart of this, we cannot felicitate ourselves with the idea that the picture was painted in the olden time, and has no relevancy to us; it fits closely to a state of things that existed nearly cotemporaneously in this country, and which has, unfortunately, not wholly disappeared even at the present enlightened day. Without referring to examples of stage-coach traveling that would set many people's bones to aching, and recall experiences of suffering and privation, we may say that it is not necessary to go far, or to search very carefully, for cases of bad roads; we may not find them with "ruts" quite "four feet deep," but we will find that it is still a prevalent practice in making, as well as in repairing, roads, to "tumble in loose stones," and to cover them over, more or less, with most unsuitable materials. In repairing (so-called) country roads, in particular, it is a common and most reprehensible practice, after tumbling into the ruts loose stones, to run a plough through the side ditches and scrape together into the middle of the road the long collected compound of road detritus, mud and weeds, and other unwholesome matter, resulting in the forming of a compost bed that lasts but a brief time, and then disappears in clouds of dust, or in mud, leaving the projecting stones to "jolt a carriage in the most intolerable manner." With abundant materials that the country furnishes, in most cases, for making respectable, if not superior, roads, at but little if any greater cost, (at less cost, in the long run,) these slip-shod practices continue. How often do we see those "hollow ways" in country roads, consisting of deep and dangerous gullies, worn down by rains that are permitted to concentrate from adjoining grounds, until the well-worn bed presents the appearance of having been designed for an artificial water-channel to drain the surrounding country, rather than for a highway for public convenience.

There was some excuse, in the new condition of our country, some years back, for not taking the lead of other countries in the civilizing art of road-making, and allowances are still to be made, in the recently settled or sparsely settled portions of the country; but in the older portions, surrounding our principal cities and villages, and containing prosperous populations, there would seem to be no palliating circumstances for the common neglect of the public highways. We seldom see the individuals composing a community practicing, in their private affairs, the wasteful economy and unthriftiness that is shown in the treatment of their roads; and it is quite as rare to find a man who is not fully aware of the wisdom of a better policy, and who is not sufficiently intelligent to know how, in some measure, to apply it, but the system of making it everybody's business and nobody's business to attend to the work prevails, and the evil is not corrected.

(To be continued.)

(Continued from page 89.)

THE STEAM-BOILER.

By Joseph Harrison, Jr., Philadelphia.

In the finding of the Coroner's jury in a recent boiler explosion in the city of Philadelphia, by which five men lost their lives, we find the following:

"That those in charge of these boilers, exhibited culpable negligence in regard to the precautions universally considered as essential to the safe management of steam-generators, and were not sufficiently experienced to render their management of such apparatus safe. A similar want of knowledge, experience and care is only too common among those using steam-power."

"That the proprietor was guilty of neglect in failing to provide a competent engineer to take charge of the steam motors of the establishment."

"In connection with this occurrence, this jury reiterates what has been already most strongly expressed under like circumstances, that official inspection of all steam-boilers should be provided by our local government, and is as essential to the safety of life and limb among our citizens as any part of our police regulations. The storage of gunpowder in our city is prohibited by law, but any one may place a steam-power magazine, with match burning, at our side or under our feet, with perfect impunity. Such magazines undermine, in fact, our most

crowded streets, and, unless properly cared for, will one day reveal their existence in fearful disaster."

There is much for reflection in these extracts, and their teachings should not be passed unheeded. In the use of steam in stationary engines, of small size, in our large cities and towns, (and from these as much harm can arise as from larger ones,) it is almost the rule to employ men of no experience or skill, who are utterly incompetent to fill the most important post of firemen. The mere fact that they themselves are in the greatest danger, fails to make them more thoughtful, and they ignorantly and carelessly go on, from day to day, hanging on the very verge of disaster, which may, at any moment, be precipitated by their own negligence. Almost unaware of the tremendous power that is in their keeping, and failing to profit by the plainest evidences of danger, a long continued immunity, often leads them recklessly to think that no harm can arise, even when danger is most imminent. And in the matter of inspection of boilers of stationary steam-engines, insisted upon so strongly, something also may be said. It is no doubt true that the regular government inspection of steam-boat boilers has been productive of good, but, at the same time, too much reliance should not be placed upon even this safeguard. It is well known that a steam-boiler may pass inspection, and be, or appear to be, at the moment, all right, but it is equally well known that in a day, or even in an hour thereafter, it may, by bad usage or neglect, become entirely unsafe. A steam-boiler may pass the most critical examination, and may stand with impunity a severe hydraulic test when cold, but a much less pressure, superadded to the strains resulting from irregular expansion, when hot, might rend the same boiler into fragments. It is plain that the fracture of steam-generating apparatus, can and may occur, under any system of construction. No amount of official inspection or special care, can entirely prevent this, and it must be set down as an imperative law, if safety is to be secured, "*that all boilers should be so constructed that their explosions may not be dangerous.*"

Having said thus much upon the general question of steam-boilers, it now becomes my province to describe the

HARRISON STEAM-BOILER,

An invention of my own, now being largely made and rapidly introduced into practical use. I had long turned my attention to the subject of improving the steam-boiler, and believing that better guiding principles were needed, I at length fixed in my mind the following axioms:

1st. That a steam-generator, of whatever form or material, must, as a paramount condition, be absolutely secure from *destructive* explosions.

2d. That it must be constructed upon a system of uniform parts, simple in form, few in number, easily made, and easily put together or taken apart, and not of costly material.

3d. That its strength should, in no respect, be dependent upon any system of stays or braces, whereby the inefficiency or rupture of one of these braces or stays, could cause greatly increased strain upon the others, thus endangering the whole structure.

4th. That its parts should not be of great weight or size, thus permitting greater portability, and greater facility for getting it into or out of place.

5th. That it must have a principle of renewal, allowing the easy displacement and replacement or interchange of any one or more of its parts, without disturbing or impairing the material or workmanship, of the remaining portions of the structure.

6th. That a boiler, whether of large or small dimensions, should have uniformly such elements of strength as would render it always capable of safely sustaining many times greater pressure than need ever be demanded of it in practice, and that its safety should not be impaired by corrosion, or the many other harmful influences which so soon and so seriously affect the strength of ordinary boilers.

7th. That the parts should be so made and put together, that in case of rupture of any portion of the boiler, no general break up of the structure could occur, the release of the pressure by such rupture merely causing a discharge of the contents, without explosion or serious disturbance of any kind.

8th. That it should be constructed so as to permit the easy and certain removal of deposit of all kinds from every portion of its interior or exterior surface.

These axioms being carried out, all else being equal, it is believed that the result must be a better and safer steam-generator than any that has preceded it. It is not important here to enter into the detail of how the "Harrison Boiler" reached its present form. Suffice it to say, that when the form of a hollow sphere and curved neck was decided upon, as shown in the illustrations herein, it seemed that the true principle had been arrived at,—that nothing more could be desired in that direction. A boiler of about seventy-five horse-power, the first of the kind, was made of these simple elements, in the spring of 1859, and put in operation at the establishment of Messrs. Wm. Sellers &

Co., Philadelphia. This boiler effectively and economically supplied steam for driving the extensive workshops of the above firm, for several months in the summer of the year above mentioned. Its trial settled the question previously in doubt even with myself, that a boiler, as hereafter to be described, could be made and used without its integrity being disturbed by irregularity of expansion and contraction, consequent upon the action of fire. In practice up to the present time it has been usual to cast the spheres eight inches in external diameter and three-eighths of an inch thick, placed in groups of two and four, making what may be called a brick and a half brick. These spheres are arranged in a straight line one inch apart between their external diameters, and are connected with each other by a curved neck about three and one-quarter inches in diameter inside at the smallest part. A series of half necks make an opening entirely through each of the spheres, at right angles to the necks previously described. These groups of spheres are called "units," and when jointed with a rebate joint, accurately made on the edge or least diameter of the half necks, fit closely together, making, when these edges are adjusted to each other, and drawn together, a perfectly steam and water-tight joint, without the intervention of cement or packing. Any number of these two and four sphere units, when placed together with break-joints, may be conveniently made into a parallelogram or other form that may be desired. The distance between the centres of the spheres in the direction of the jointed or half necks, when the units are laid together, is the same as the distance in the transverse direction, thus making a uniform section or slab of any given length or breadth. Wrought iron tie-bolts pass through each line of spheres in the direction of the half, or jointed necks, connecting at each end with caps that close up the external orifices of the section. One of the caps, called a blank cap, is made to receive a T-head at one end of each bolt; the other end of the bolt passing through the opposite cap, and ending outside with screw and nut. It will be readily seen that these tie-bolts, when properly tightened, will bind all the units in one section firmly together. A section or slab of six spheres wide, the upper rows twelve, and the four lower rows thirteen spheres long, will make a boiler of about six horse-power.

In setting a boiler ordinarily, for stationary purposes, one or more of the sections are placed on edge, at an angle of about forty degrees, side by side, usually one inch apart between the sections, the upper corner on the bottom line being supported on a cast iron rail or bearer, the lower portion resting on a chair, adapted to the purpose, placed

behind the bridge-wall. A common steam-pipe, taking steam from the upper caps, connects any number of sections together. A similar pipe, in like manner placed at the bottom corner of the section, makes a water connection between any number of sections. To avoid binding of the parts from irregular expansion or disturbance of any kind, the steam and water-pipes are made up of short pieces, joining with spherical joints, held together with tie-bolts, after the manner of the units. By this means a flexible, or articulated connection is made, that prevents all trouble in joining the sections together.

No attempt is made to provide steam room other than the capacity of the spheres in the upper angle of the sections above the water-line. The amount of steam space is a little less than one-third the contents of each section, the remaining portion of the section being filled with water. It is found in ordinary practice with the largest boilers that the steam space allowed as above, is quite sufficient. The heated products of combustion, rise from the grate, passing between the sections, and amongst the spheres, and over the bridge-wall, finding exit at length towards the chimney at the lowest and coldest part of the boiler. A cast iron guard is inserted between each slab, nearly horizontal, a short distance below the water-line. This guard prevents active heat from reaching the steam spheres, but at the same time sufficient heat reaches the upper angle of the boiler, to dry and partially superheat the steam ere it reaches the outlet to the steam-pipe at the upper cap. Priming is not usual in this boiler, with ordinary fresh water, and its peculiar construction causes it to be its own superheater, without separate apparatus. It is not essential that a stationary boiler should be set exactly as described, as the units may be built up vertically, horizontally, or in any irregular manner, best suited to the circumstances of the case. A stationary boiler set after the manner first indicated, and heretofore most generally adopted, has given very good and very economical results, when compared with other boilers having the best reputation. A boiler for marine purposes may be made in the form of a cube, and may be set without brick-work.

Having, as I think, in the previous pages of this volume, fairly proved that cast iron is to be preferred to wrought iron as a material for steam-boilers, let me say a few words in regard to the advantages of the former material as used in the "Harrison Boiler." Mr. Zerah Colburn, late editor of the London *Engineer*, and now editor of the new magazine published in London, called *Engineering*, has written much and very ably on the steam-boiler. His opinion, therefore, is entitled to great respect. In a paper on steam-boilers, read by him

before the Institution of Mechanical Engineers, at Birmingham, on May 5th, 1864, in alluding to mine, he says: "Although it cannot be said that cast iron is in itself a strong material for boilers, yet it will be seen that in the form now described, it affords greater absolute strength against bursting than is possessed by any form of plate iron boiler. The 'units' are cast upon green sand cores, so placed that they cannot alter their position in the flask by any force short of what would be sufficient to crush them to pieces; the thickness of metal in the spheres is therefore uniform throughout. In a 'unit' of four spheres, each sphere having an internal diameter of seven and a quarter inches, the whole area of the plane in which a bursting pressure could act, taken through the eight openings of the four spheres, is two hundred and twenty square inches, whilst the least section of iron resisting this pressure in the same plane is twenty-seven and a half square inches. The iron employed is an equal mixture of Glengarnock, Carnbroe and scrap. Its tensile strength may be safely taken at five and a half tons to the square inch. At this rate the bursting strength of the units would be one thousand five hundred and forty pounds, or nearly three quarters of a ton per square inch."

And again, Mr. Colburn, in a paper read before the British Association for the Advancement of Science, at Bath, in 1864, says: "In ordinary boiler-making the geometrical advantage of the hollow sphere cannot be turned to account. It cannot be produced economically in plate iron, nor if in plate iron, could it be advantageously employed in a steam-boiler. The hollow sphere has this property, to wit: with a given thickness of metal it has twice the strength of a hollow cylinder of the same diameter. This is upon the assumption (which is correct when the cylinder is of a length greater than its own diameter) that the ends of the cylinder offer no resistance to a bursting pressure exerted against its circumference. Under over-pressure, a closed cylinder would take the shape of a barrel, and if of homogeneous material and structure, it would burst at the middle of its length, in the direction of its circumference. The circumference of a sphere of a diameter of one, being 3·14159, the sum of the length of the two sides of a cylinder of the same diameter, and having a plane of rupture of the same area, is 1·5708, or exactly half as much."

And in the same paper, he says: "The tensile strength of cast iron varies between five tons and fifteen tons per square inch. Considered as a material for boilers, only the minimum strength should be regarded." "Cast iron boilers of eight feet in diameter, and of great length, were at one time made, but these were manifestly objection-

able. The spherical form of a moderate diameter is preferable, and whatever is the strength of a riveted wrought iron cylinder, that of a cast iron sphere of the same diameter and same thickness of metal, will be the same. Plate iron of a strength of eighteen tons per square inch is virtually weakened to ten tons by the loss in riveting, and as the hollow sphere is twice stronger than the hollow cylinder of the same diameter and thickness, the cast iron having no joints, becomes equal in this comparison to the wrought plates."

"If we could always count upon the maximum strength of iron, to wit: twenty-seven tons per square inch for wrought and fifteen tons for cast, a fourteen feet cast iron sphere would have the same strength to resist bursting as the seven feet cylinder of the Lancashire forty-horse boiler, supposing the same thickness of metal in each case." "But there is no occasion to make a boiler as a single large sphere, for it is now ascertained from extensive experience that hollow cast iron spheres of small diameter, do not retain the solid matter deposited by the water. Small water tubes, and indeed all small water spaces in ordinary boilers, always choke with deposit when the feed-water contains lime, but cast iron boiler spheres, although they may be temporarily coated internally with scale, are found to part with this whenever they are emptied of water. *This fact is the most striking discovery that has been made in boiler engineering.*" It removes the fatal defect of small subdivided water spaces, which can now be employed with the certainty of their remaining constantly clear of deposit. "This discovery has been made in the use of the cast iron boiler invented by Mr. Harrison, of Philadelphia, United States." "In Manchester, with feed-water taken from the Irwell, or from the canal, a hard scale is soon formed in the ordinary boilers; but in the cast iron boiler, a succession of thin scales of extreme hardness are found to form upon, and to become detached of, themselves from the inner surfaces of the water spheres. The scales are blown out with the water at the end of the week, and only small quantities can be found when purposely sought for. A pint of loose scales and dirt is the most that has yet been found in a careful internal examination, after nine months' daily work." "None of *the cast iron is removed with the scale.*" "The self-scaling action which has been found to be the same in all cases where the boiler has been worked, can only be explained by conjectures, which it is not, perhaps, necessary to introduce in the present paper. It deserves the careful investigation of the chemist and mechanical philosopher, with whom the author prefers to leave the subject."

The property of casting the scale, as stated by Mr. Colburn, was

not aimed at when the Harrison Boiler was designed, and such a result was entirely unexpected when it was first put in use. It is true, nevertheless, that after three months' trial of my first boiler, at Messrs. William Sellers & Co., in 1859, no scale or other deposit of any kind was found therein; all that may have been formed, having been removed by merely blowing out once a week. Still, this short experience seemed hardly sufficient to establish a rule. Fearing and anticipating the usual trouble from deposit, and having a form of boiler that admits of perfect access to all its interior surface from without, by withdrawing the bolts, one at a time, I devised and made a very perfect instrument for removing the scale with perfect certainty, by mechanical means. But in addition to what has been stated by Mr. Colburn, a continued experience, running through many successive years, in Philadelphia and elsewhere, has proved that, as a general rule, the Harrison Boiler *does* regularly shed its scale by blowing it out, under certain directions, once a week. In no case has it been found necessary to use the instrument designed for removing the scale. There are, I think, several reasons why this peculiar form of steam-generator should have this property of shedding its interior scale or deposit. In the first place, cast iron, as a material for steam-boilers, has not the same tendency towards continued oxidation as wrought iron. Rust on the inner surfaces of a boiler, when made of the latter material, combines with the deposit, causing it to harden and cling with great tenacity to the metal upon which it rests, making it much more difficult to remove than simple earthy or chemical deposit. I do not think that the hollow sphere, in itself, has any special quality for throwing off scale; still I think it will be seen that the hollow sphere, in connection with the curved neck, may have this quality in a great degree. If the form of the interior of one of the units of the Harrison Boiler is carefully examined, it will be found that none of its inside surface makes a complete arch or a continuous ring. A hollow sphere, without opening of any kind, would bind deposit to its inner surface, just as it is bound in a tube of equal diameter, and from which it is often so difficult to be removed. In every instance in the "units" of the Harrison Boiler, the curved neck comes in to break up the continuous ring, and removes the abutment of the arch. What follows, as far as interior deposit is concerned, would seem obvious. When the deposit is fixed upon the inner surface of the unit, both metal and deposit are about the same temperature, and consequently nearly in equilibrium. The boiler is blown out under full pressure at the end of each week, just after the fires are drawn,

leaving the walls of the furnace at, perhaps, red heat. At one hundred pounds pressure to the square inch, the temperature of the "units" would be over three hundred degrees. The excess of heat in the furnace walls might raise this temperature to four hundred degrees or more, thus slightly increasing the size of the unit in every part. It is well known that earthy or chemical matter will not expand equally with metal, and from this cause a disturbance, no doubt, takes place, soon after the boiler is emptied, between the metal and the inside coating of deposit, causing the latter, perhaps, to crack or loosen itself. The boiler is allowed to remain empty until quite cold, the units then returning to the size they possessed before heat was applied to them. The contraction of the casting to its lowest point, and the non-contraction of the deposit in an equal degree, still further, (it is fair to infer,) disturbs the integrity of the deposit, and not arching itself as in a tube, it is no doubt partially thrown off, and in due course of circulation, finds its way to the lower parts of the boiler. When the boiler is again filled with water and fired, the partially clinging fragments of scale still remaining on the inner surface of the units, would evidently soon be removed, as the boiler became active in generating steam. I have not been able to learn exactly what goes on inside the boiler, but this particular form evidently does, almost with certainty, shed its scale when in use, and treated as described.

I have endeavored to show why it possesses this singularly remarkable and most useful property. In but one instance, as far as has come to my knowledge, in the use of several hundred of these boilers, has any difficulty arisen with deposit. This case occurred in the vicinity of Philadelphia, where water, taken from a well, formed a peculiar deposit very rapidly, which did not remove itself with blowing out, and caused consequent difficulty in the use of the boiler. It was at length taken down and reconstructed, and the water thereafter taken from the regular city supply. Since the change in the water no trouble has arisen from interior deposit, and it is now giving great satisfaction.

CIRCULATION OF WATER.

It is believed that the steam-boiler under consideration has many advantages in its water circulation, or rather in the facility with which the steam is delivered into its proper place, after its generation. When set as is usual at an angle of about forty degrees, the currents of water, in each section, when generating steam, ascend along the line of spheres nearest the fire, and through the intersecting necks,

carrying with these currents, the accumulating steam as it is thrown off from the inner surface, and delivering it at the upper angle, or steam-room portion of the section. The descending water-currents, at and near the water-level, find their way downward along the upper ranges of spheres, and through their intersecting necks, reaching, at length, the lower angle of the sections, from which point the circulation is continued, and goes on as before.

It should be noted that each section of this generator, no matter how large the whole structure may be, has in itself a uniform, separate and thorough system of water and steam circulation. In fact, each section is a distinct boiler. This system of water circulation throughout all the parts of each section, always regularly kept up, has much to do with the removal of interior scale after it has become detached from the inner surface of the "units," and may be explained as follows:

In actively generating steam, the water and steam circulation must necessarily be very active at the hottest parts of the boiler. This keeps the loosened scale or deposit in suspension for a time. But when it reaches the lower portion of the section, where the circulation is least active, from the water not being highly charged with steam, the deposit has a tendency to remain at the bottom of the section, at or near the outlet, ready to be discharged at the first opening of the blow-off cock.

Much has been attempted in the matter of more perfect circulation of water in steam-boilers, and consequent disposal of the steam after its generation, even to the using of compulsory means for effecting this important object. From the peculiar uniformity of the parts, and the manner in which the sections are set, it is believed that this boiler has a more perfect system of water and steam circulation, than any that has preceded it.

FIRE CIRCULATION.

The boiler under consideration, it is believed, has several advantages in the application of heat thereto. Its peculiar form softens the lines of circulation for the heated products of combustion, leaving no abrupt turns or out-of-the-way corners, so often found in the more complicated boilers, and at the same time presenting a series of uniform channels, with their equally uniform surrounding surfaces for taking up the heat. Unlike the long and narrow tube of the tubular boiler, each channel of fire circulation in this, is in full connection with all the others, both vertically and laterally, causing a better blending

of the elements that support combustion, and thus maintaining it for a longer period than can be done in the long narrow tube.

It has been proved by repeated experiment that tube fire surface (say, in tubes of two inches external diameter and under,) has a greatly reduced value, after the first two or three feet from the fire, when compared with fire-box surface. In some carefully conducted experiments made under my notice several years ago, at St. Petersburgh, Russia, it was found, in boiling water in the open air, that copper tubes of two inches external diameter, and one-tenth of an inch thick, laid horizontally, were very nearly equal to fire-box surface in evaporating power, for a distance of two and a half feet from the fire. Beyond that distance their value fell off rapidly, and five feet, with a most intense fire, seemed to be the maximum of really valuable fire surface. Between the ninth and tenth foot, (the latter being the extreme length of the tubes,) water could not be raised in temperature to two hundred and twelve degrees, after hours of continuous firing.

These experiments, often repeated, and always with the same result, were made with a fire-box twenty inches diameter and twenty inches high, out of which proceeded, horizontally, four copper tubes of the dimensions above stated. Great care was taken to ascertain the exact evaporating value of each separate foot of tube surface in the direction of their lengths, as well as the value of fire-box surface.

Let us consider, for a moment, why so large a portion of the tube surface had so little value. Flame, or inflammable vapor, entering a tube of small diameter, may, at the moment of entrance, be in full combustion, and have a temperature nearly or quite equal to the source from whence it springs. Passing into a tube one and eight-tenths inches internal diameter, surrounded by boiling water, the metal in the tube would have a temperature, at the pressure of the atmosphere, of not much above two hundred and twelve degrees. The vapor coming in contact with this comparatively low temperature of the tube, would soon be reduced below the point of combustion, and from that moment, no matter what heat-giving properties it might still possess, they would be of no further effect, and to the end of the tube the vapor would give off heat only as heated air.

MAINTENANCE.

From the small size of the component parts, and the simple manner in which they are put together, it will be seen that injured parts of the Harrison Boiler can be renewed with great facility. A sphere may crack, or portions of the sections, nearest the fire, may, from

lowness of water, become overheated and spoiled. The taking out of a few bolts, and the removal of a small portion of brick-work in a stationary boiler, permits the displacement of the injured parts, without disturbing the uninjured portions of the structure; whilst replacement being equally convenient, an injured boiler by renewal, *and not by repairs*, properly speaking, (for no injured part is ever patched or mended,) is soon rendered as good as new.

A large proportion of the whole boiler need not require renewal. Parts taken out, and unfit for use, are in a most convenient form for remelting, and in this respect the old material has much greater value, compared with first cost, than the worn-out wrought iron boiler. The latter, from great size, and the difficulty and cost of getting into a more convenient shape for reworking, is often almost unsalable.

TRANSPORTATION.

The facility with which this boiler can be maintained, will explain why it is easy of transportation. Usually it is sent from the workshop in sections very convenient and safe to handle, each weighing about a ton. These sections can be put into place, if necessary, through an opening five feet long and one foot wide. If it is required to still further reduce the size and weight of the separate parts, a section may be taken to pieces, so that no portion need weigh more than eighty pounds. Thus a boiler, no matter what its ultimate size may be, can be carried, in detail, in a man's hand, and may be put through an opening one foot square. The handling, transporting and placing of the unwieldy wrought iron boiler, is always a source of great expense, —often of danger and delay. Many a boiler has been run much nearer the point of disaster than it would otherwise have been, had its removal and replacement been a matter of more easy accomplishment. Many a disastrous explosion has occurred, and many a valuable life has been lost, for no better reason.

EXTERNAL CLEANING.

It has been shown how this boiler is kept clean inside. In the economical use of a steam-boiler it is of much importance that the outside should also be kept clear from all deposit tending to hinder the absorption of heat. It is always difficult, and sometimes impossible, to keep the ordinary steam-boiler free from soot and other deposit on its fire surface, whether in flues, plain cylinders, or the other numerous forms in which it is made.

The fire passages of the Harrison Boiler, being uniform, and all in connection with one another, external cleaning becomes a very simple process. Through the small doors just above the furnace doors, easy access is had to the interior fire passages, and a small jet of steam blown in various directions through these small doors from a hose attached to the boiler, having a pipe and nozzle arranged for the purpose, will effectually remove all soot or other deposit, keeping the spheres as clean outside as when first made.

TENDENCY TO RUPTURE.

Steam at ordinary working pressure has but little tendency to rupture any of the parts of this boiler, and might almost be left out as an element of harm, from the fact already mentioned, that the calculated bursting point is very many times greater than the working pressure of an ordinary high pressure steam-engine. Neither has the steam pressure any great tendency to separate the joints, as the necks being but three and one-quarter inches in inside diameter, might be held together under a pressure of one hundred pounds per square inch, with a bolt no larger than would sustain a strain of about eight hundred and thirty pounds.

Allusion has been previously made to the evils that affect all boilers from irregular expansion when in use. It is equally necessary in the Harrison Boiler to guard against this influence. It may be well here to consider this most important feature more fully. The powerful and irresistible action of this force begins its work at the moment fire is first applied to a steam-boiler, and little by little, too surely impairs its strength. It is most difficult to control when the material is in such form as not to admit of compensation or allowance, when subjected to its injurious effects. In ordinary boilers made of wrought iron, it is practically impossible to arrange the parts so as to prevent irregular expansion, and consequent undue strain from this cause. As it has been shown that it is equally impossible to make and put such boilers together when new, without undue strain, we have here two most powerful influences at work, tending to rend the parts asunder, (entirely irrespective of steam-pressure,) the importance of which as elements of danger are seldom, if ever, taken into account. Take a plain cylinder, if you please, the most simple form into which wrought iron can be put to make a steam-boiler. Put a fire under such a boiler, expending its most intense heat upon a short portion of one-half of its lower diameter, at the end over the fire-grate, the products of combustion thereafter coursing along

the whole length of the remaining half diameter, until the outlet to the chimney is reached. Under these circumstances, the lower line must be very materially increased in length over the upper line, and the whole structure will be then subjected to a series of most complicated strains, the position and nature of which we can only conjecture, and consequently cannot provide against. Extra thickness of material will not always remedy, and might even aggravate, the evil.

In more complicated boilers, this terrible ordeal of fire is often yet further intensified. Make such boilers of cast iron or other brittle material,—putting them into shape, entirely free from strain, (if this were possible,) and when filled with water to the proper level, let them be fired in the same manner as if made of wrought iron. That such boilers would break in pieces ere long is not doubtful. Made of wrought iron, they might not break up at once, but their greater tenacity would give them no immunity from the harmful influences that had so soon destroyed their more brittle competitor, and which might, in the end, prove alike fatal to both. It is not a very hopeful view, when we consider that these undue strains are not lessened when the boiler becomes weakened by corrosion, or has its strength impaired by any other cause.

The Harrison Boiler in its manufacture and use, is not liable to serious injury from undue strain, or from irregular expansion. Cast iron expands less at the same temperature than wrought iron, and this difference might seem likely to interfere with the tightness of the joints. But when it is considered that the heat is first applied to the spheres, and thence through the water to the bolts, the latter must always have a less temperature than the spheres, which practically brings both nearly in equilibrium. A due proportion being maintained between the bolts and the spheres, no trouble need arise from irregular expansion when the boiler is not unfairly used.

DURABILITY.

In an experience of several years with this boiler, no evidence of serious gradual depreciation has ever shown itself in any of its parts. Corrosion affects it but slightly. Its self-cleaning properties usually prevents overheating consequent upon interior deposit.

Breaking of spheres happens so seldom as scarcely to need mention, amounting to only about one-fiftieth of one per cent. in an aggregate of one hundred and fifty thousand spheres put in use. In fact, except from overheating or "*burning*," arising from too low water or other cause, and consequent warping of the "units," which, of

course, destroys the accuracy of the joints, I have not found any decided marks of depreciation after long use. When compared with the wrought iron boiler, it would seem practically indestructible.

SECURITY FROM EXPLOSION.

By what has been adduced, it must be seen that the Harrison Boiler is safe from destructive explosion. It is not, however, maintained that it cannot be burst in some of its parts, or that it might not, under certain exceptional circumstances, do personal injury, consequent upon the sudden discharge of water or steam. But it *is maintained*, that under no circumstances can it "*rend and scatter large masses of material, liberating at the same time large volumes of highly charged water and steam.*" Spheres have cracked, (always singly,) but they are not broken into fragments, thus causing a sudden discharge of the contents of the boiler. Consequent leaking at the fractured part may, for the time being, and until renewal, prevent the use of the boiler. Instances have occurred where a cracked sphere has been left in its place for several days without inconvenience or stoppage.

On page 131 of the February number of this Journal, for 1867, will be found a report of the "Committee on Science and the Arts," of the Franklin Institute, giving a detailed account of certain most severe tests that the Harrison Boiler was put to, in the effort to destroy it by steam-pressure, and other means. The attempted destruction utterly failed. Attention is called to this report as exhibiting some very remarkable results. When it is considered that eight hundred and seventy-five pounds per square inch of steam-pressure failed to burst any of the spheres in one of the sections,—that under such severe test every joint becomes a safety-valve, and when it is rendered certain, that under all circumstances of fracture the general integrity of the whole structure can be surely maintained, (a point most positively insisted upon,) then but slight injury can arise, in any contingency.

CONCLUSION.

Considering the plan, material and mode of manufacture of the Harrison Boiler, let me now revert to the *axioms* laid down by me as guiding principles in making a steam-boiler, and see how far they have been carried out.

1st. The boiler under consideration *is theoretically and practically safe from all destructive explosion.*

2d. It is *constructed upon a system of uniform parts, few in num-*

ber, easily made, and easily put together or taken apart, and not of costly material.

3d. *Its strength is in no respect dependent upon any system of stays or braces, whereby the inefficiency or rupture of one of these braces or stays can cause greatly increased strain upon the others, thereby endangering the whole structure.*

4th. *Its parts are not of great weight or size, and may be easily transported, or put into or be taken out of place.*

5th. *It has a principle of renewal allowing the easy displacement and replacement or interchange of any and all of its parts, without impairing or disturbing the material or workmanship of portions not needing renewal.*

6th. *Whether of large or small size, it has uniformly such elements of strength as will always render it capable of sustaining many times greater pressure than need ever be demanded of it in practice, and its safety is not impaired by corrosion, or the many other harmful influences that so soon and so seriously affect the strength of ordinary boilers.*

7th. *Its parts are made and put together, so that in case of rupture, no general break up can occur. Its contents may be discharged, but no explosion or serious disturbance of any kind can take place, consequent upon such discharge.*

8th. *It is constructed so as to permit the easy and certain removal of deposit of all kinds, from every portion of its interior and exterior surface.*

It is assumed that the better "guiding principles" in the construction of a steam-boiler have been fairly carried out,—that all other matters are at least equal, and that the result *is* a safer if not a better one than any that has preceded it.

ITS PRACTICAL AND COMMERCIAL SUCCESS.

Until the spring of 1864 no effort was made to test the commercial merits of the Harrison Boiler by offering it for sale. In the early part of 1863 a boiler of fifty horse-power was put up experimentally at the establishment of Messrs. John Hetherington & Sons, Manchester, England, and subsequently a smaller one at the same place. Both of these boilers worked well and gave great satisfaction up to the middle of 1864. Orders were also received for several others, to be erected in the neighborhood of Manchester. Several hundred tons of this boiler, made in England, were imported into this country in 1864, and put into operation into Philadelphia and other places.

Since October, 1865, I have been manufacturing the boiler at my own foundry on Gray's Ferry Road, Philadelphia. There are now at work, in the United States, boilers on my plan, varying in size from five to three hundred horse-power, with an aggregate of twelve thousand horse-power, all put in operation within the last two years and a half. Most of these have been erected in Philadelphia. Others in various parts of the Union, from Michigan to Georgia, and from Massachusetts to Missouri. Some have gone to Canada, and others to South America, Liberia and New Zealand. I have now large orders for the Eastern, Western and Southern States, and for our own city, with a constantly increasing demand.

The Harrison Boiler has met with more favor at the hands of the public, than could have been expected, considering the novelty of its material and form, and the prejudice that so naturally attaches to any effort aiming at an almost entire overthrow of a long established system. Its peculiarities invite criticism, and it would not appear strange if even many of those best acquainted with the subject generally, should pass this by with little attention, thinking at a glance, that it was so much out of the beaten track, as to seem utterly impracticable.

Nothing in connection with the use of steam has been so much discussed as the manner of making the apparatus for its generation, and to have called out, for a century past, such an army of thinkers on a subject having in the abstract but a few simple elements, there must have been, and no doubt still is, some inherent defect in the plans heretofore and now used. The field is evidently not yet exhausted, if we consider that in the United States alone, forty-nine patents were issued in 1865, and fifty-eight in 1866, for steam-boiler improvements; the lowest number being nearly double that of any preceding year.

If, in these pages, I have added to the stock of information tending to make the use of steam less dangerous to life and property, I have attained something. If I have been instrumental in producing a steam-boiler, that will take its place permanently, as a means of rendering steam generating apparatus more safe from destructive explosion, I shall have attained something more. If in my effort to improve a much used and much abused object, manifestly demanding improvement, I have only succeeded in proving a fallacy—I shall still have my reward.

JOSEPH HARRISON, JR.,
Rittenhouse Square, Philadelphia.

From the London Engineering, No. 29.

THE STEEL RAIL QUESTION.

There are few questions which now possess the same importance to railway engineers and railway companies as that of the substitution of steel for iron rails. It involves not only the broader consideration of the durability of rails, but it embraces also nice questions of the relative strength of steel and iron, of their cost when new, and their value when worn out. On the occasion of the recent discussion of Mr. Price Williams' paper at the Institution of Civil Engineers, the engineering advisers to the railways of the United Kingdom and the colonies, dealt practically and commercially with these questions, and we cannot interpret the result of the discussion otherwise than as a verdict in favor of steel rails, although we are still wanting precise data upon which the extent of their superiority over iron may be definitely pronounced.

Mr. Williams, in dealing with the question of the life of a rail, endeavored to bring it as far as possible to that of its mechanical service, and he made the tons moved over a rail the standard of wear, rather than the number of years during which it might be in use. Two rails, of equally good quality might be worn out, the one in three years upon one line, and the other in twenty years upon another, the wear following the total weight and the speed of all the trains running over the rail. The former standard approaches precision where that of the surface in years does not; but even the tons of traffic borne does not form a precise standard, inasmuch as the wear is related—we will not say in what ratio—to the speed, and to the maximum weights upon a wheel, besides being closely related to the general condition in which the line is maintained, and to that of the rolling stock. Mr. Williams found, from the results of careful observation and record, that good iron rails bore from twelve to fifteen million tons of moderately fast traffic and thirty-eight million tons of slow traffic, while Bessemer rails had borne ninety-five million tons of slow traffic without being nearly worn out on even the single face. It seems to be a notion that rails on down gradients should not wear out as fast as those on up gradients, and thus the question of the pitch and direction of gradients might be considered to enter also into that of wear. But the vertical pressure of a train or a single wheel upon an inclined rail is the same whether the wheel be rolling up or down, and it is the vertical pressure taken in connection with the total force of motion acting upon the train—or the work stored up in it—that determines the question of wear; and the destructive forces are the same, although the engine force may not be the same, in moving a train down a gradient, along a level, or up a gradient, the speed being supposed the same in each case. By destructive forces we mean the conjoined effects of vertical pressure and advancing motion. The utilized bite of the engine wheels must be harder

in going up than in going down a gradient; but it is not certain that the longitudinal force exerted along the rail by what we call the adhesion of the engine produces any sensibly destructive effect at all. In other words, supposing no slipping, it is not certain that any more wear attends the working of a locomotive in the ordinary manner than would attend its motion if towed over the line at the same speed. The friction, or so-called adhesion, whereby locomotives are self-moving, is demonstrably simple static friction, and, so long as there is no slipping of the surfaces in contact, it is not clear that the rails are sensibly injured by the longitudinal thrust of the driving-wheels acting upon them. Mr. Williams has found that, with the same tonnage on ascending and descending gradients of the same pitch on the Great Northern line, the falling rails wear out much the sooner, no doubt because of the greater speed maintained upon them. Thus, on a descending gradient of one in two hundred, between Hatfield and London, the rails are worn out in three years with an average traffic of twelve million tons. On a rising gradient of the same pitch, not far from Peterborough, the same quality of rails last six years, and bears twenty-five million tons.

The questions of durability and of strength have been decided, and, we may say, without any qualification or deduction, in favor of the steel rail. There were ninety-five and a half million tons over the Chalk Farm rail, and the Bessemer rails at and near Crewe Station have borne, in one part of the line, fifty-two million tons, with a wear of only five-sixteenths of an inch, and in another eighteen and a half millions with but three thirty-seconds of an inch wear.

As to strength to bear heavy strains and sudden and severe blows, the steel rails are almost beyond comparison with iron rails. Supported upon five feet bearings, steel rails were found by Mr. Kirkaldy to bear in one case over eighty thousand pounds applied at the centre, and not one bore less than twenty-five tons, while the iron rails, tried in the same manner, bore from thirty-six thousand pounds to fifty thousand pounds only. Mr. George Berkley has tested steel rails on three feet seven and a half inch supports, to a central bending strain of sixty-four and a half tons, and he has found the tensile strength of the steel to be from forty-one and a half to forty-three and a half tons per square inch, according as the steel was from the web or the head of the rail.

As for resistance to impact, Mr. Berkley not long since tested some Bessemer axles, of nearly the same quality as steel rails, with some most extraordinary results. They were railway carriage axles, three and three-quarter inches diameter, seven feet two inches long, and were placed upon bearings three feet apart. A falling "tup" or ball, weighing fourteen hundred-weight and three quarters, or nearly three-quarters of a ton, was then allowed to drop upon them from heights, successively, of five feet, ten feet, fifteen feet, twenty feet and thirty-five feet. The first axle bore five of these blows, and was deflected twenty-five inches, but there was no appearance of fracture. The second, after two blows of ten feet and fifteen feet, was then nicked with

a cold chisel expressly to break it, the fall then employed being twenty-five feet. A third axle, struck with a fourteen hundred-weight ball, bore blows from a height of eleven feet six inches, seventeen feet and twenty-three feet six inches, and finally broke with a blow of thirty-six feet fall. A fourth was broken by two successive blows from a height of thirty feet each. A fifth bore five blows, the fall rising progressively to thirty feet, but the axle was not broken. A sixth bore blows successively, the fall being ten feet six inches, and was then nicked and broken with a fall of twenty-five feet.

But axles are not rails, and Messrs. M'Clean and Stileman made some trials of the breaking strength of seventy-three pound steel rails and eighty pound iron rails for the Furness and Midland Railway Company. The rails were keyed in chairs four feet apart, and a five hundred-weight tup or monkey was employed. A fall of four feet produced no set in the steel rail, a fall of ten feet gave one inch set, and a fall of twenty feet two and a quarter inches set only. The rail could not be broken with the means at hand. A second rail took a set of only one inch from a twenty feet fall of the same weight, and a set of one and a half inch from a further blow of twenty-six feet fall. This, too, could not be broken. The iron rails, nearly ten per cent. heavier, broke, the one with a six feet fall of the same weight, the other with an eight feet fall. The sets were but trifling, showing, apparently, brittleness of the iron.

The durability and strength of Bessemer rails being thus proved and conceded, the next questions are those of first cost, interest on cost, and the value of the old material when worn out. If the steel rail last twenty years, where the iron rails last three, then the railway company will lay out of the whole cost of the steel rails for twenty years, where with iron the first cost is not only less, but a considerable sum is recovered at the end of three years towards further renewal. Then, again, it becomes a question whether it is fair, after what has been seen, to compare iron and steel rails of equal weight, and whether compound interest or simple interest is to be considered. It seems reasonable to suppose that the full advantages of steel rails would be had with considerably less weight than is employed with iron. Mr. Hawkshaw has expressed the opinion that the time has arrived when the weights of rails to bear high speeds, should be increased, and that the weight of steel rails should not be less than seventy pounds or eighty pounds per yard; but this is not opposed to the proposition that steel rails of lighter section than that of iron rails may be employed without sensibly diminishing the greater comparative durability of the former. It will perhaps be more satisfactory, however, to count upon equal weights in both cases, leaving any incidental advantage thereby gained for steel as an additional benefit. Steel rails are made at prices of from £12 10*s*. to £16, and iron rails cost from £7 to £8; if guaranteed, as are those made for the Great Northern, £9 per ton. It is doubtful, however, whether really good steel rails can now be had for less than £15, while really good iron rails cost £8 to £8 5*s*. Mr. Schneider, of Barrow-in-Furness, has publicly stated,

however, that first-class Bessemer rails may probably be made to yield a fair profit at £13, and we may perhaps look to this as the future price of steel, under extended competition and for a considerable time to come. We cannot yet say how many iron rails a steel rail may be, with certainty, depended upon to wear out. But we believe that no competent engineer who has expressed himself upon this subject considers the ratio of durability as less than three to one. In such cases we cannot adopt any precise data, but the general result of the comparison of the first cost, compound interest, and cost of renewal is in favor of steel rails, when these are assumed to wear out each three iron rails. Mr. Johnson, of the Great Northern Railway, has made a careful calculation, the results of which are embodied in a table of much value, showing the cost, year by year, and the total cost for twenty years, of steel and iron rails, at from £12 to £15 per ton for the former and from £7 to £10 per ton for the latter, renewals being allowed for, and compound interest allowed at 5 per cent. on all money as spent. Even this does not show the full value of steel, in the increased safety of the line, and in the lessened disturbance of relaying, &c.; but the results do show that steel may be adopted with confidence, and especially upon all lines where the traffic is great, and the consequent wear of rails rapid. From what Mr. Johnson has said, we cannot doubt that the Great Northern line, which has a few thousand tons of steel rails now in use, will eventually be relaid with them throughout. The Crewe works are of a capacity to make three hundred tons of steel rails a week, and between fifty and a hundred miles of steel rails are already down on the London and North-Western line. Mr. Harrison of the North-Eastern, is using them in considerable quantities. Mr. Fox, of the Bristol and Exeter, has found them to be far more durable than iron rails. Mr. Fowler and Mr. Hawkshaw are using them in their practice; Messrs. M'Clean and Stileman have recommended their use; Mr. Berkley has abundantly shown their great strength; and altogether the judgment of the profession may be said to have been distinctly pronounced in their favor. When worn out, Bessemer steel makes valuable scrap, worth from £7 to £10 per ton. Mr. Schneider, of Barrow-in-Furness, and who, if any one, should know, has stated that the quality of Bessemer metal, as now made, admits of its being cut up, piled, reheated and welded with nearly the ease, cheapness and certainty of iron itself. He finds no difficulty in welding; and the value of worn steel rails may be accepted therefore as at least in the same proportion to their original cost as holds good in the case of iron rails.

From the London Engineering, No. 56.

THE SUPPORTING POWER OF PILES.

Mr. Wm. J. McAlpine, a well known and eminent American engineer, has furnished us with the following formula for ascertaining the safe load which piles will sustain, his experience being derived from a

number of experiments made during the construction of the dry dock at Brooklyn, U. S., between the years 1845 and 1849. The foundations upon which the docks were constructed, consisted of about five thousand piles of round timber, from six to twelve inches in diameter, and driven from twenty-five to thirty-five feet deep into the ground, by means of piling machines provided with rams of about one thousand four hundred pounds weight, falling through a height of forty-five feet, between guides bound with smooth iron straps. The material over the whole surface, and to the full depth into which the piles were driven, was homogeneous, consisting of a fine sharp sand, which offered a very uniform resistance. Mr. McAlpine found that a pile thirty feet long, six inches diameter at the smaller end, and twelve inches diameter at the larger end, sustained about one hundred and fifty tons after it had been driven home, until it ceased to move by a hammer of a ton weight falling through thirty feet, and that, generally, piles of whatever size, and driven home by any weight, possessed a supporting power, as shown in the accompanying formula. This power was ascertained by loading the pile to be tested with successive weights of about five tons each, and leaving these weights in position for not less than half an hour.

The piles, driven home by a ram of two thousand two hundred and forty pounds, falling through thirty feet, generally moved under a load of one hundred and twenty-five tons; their supporting power is therefore taken at one hundred tons.

Let W = weight of the trial hammer = 2240 pounds.
" W' = weight of a hammer proposed to be used.
" F = fall of the trial hammer = 30 feet.
" F' = fall of hammer proposed to be used.
" Y = sustaining power of the trial pile.
" Y' = weight which the proposed pile will sustain.
" X = extreme weight in tons which the pile will sustain.

1. Then with the same weight of hammer as used in the trial pile and any other fall,

$$Y' = \frac{100\sqrt{F'}}{5{\cdot}48}$$

2. And with the same fall, and any other height of hammer,

$$X = \frac{X + 2\,Y'}{3};$$

or, substituting for X and Y' their values as found above,

$$X = 12{\cdot}23 \times \sqrt{F} + \frac{W'\sqrt{F'}}{400}.$$

Thus, taking the particulars, as stated above, of weight and fall of hammer used in driving the pile experimented with during the construction of the Brooklyn dry dock, we have—

$$X = 12{\cdot}23 \times \sqrt{30} + \frac{2240\sqrt{30}}{400} = 100 \text{ tons.}$$

From the London Engineering, No. 52.

CHILLED WHEELS FOR RAILWAYS.

We find a long letter on the above subject by W. W. Evans, who has for about thirty years been engaged in railway construction in the United States and in South America. The writer speaks in the highest terms as to the efficiency, economy and durability of these wheels. Thus he says: "Having used all classes and kinds of wheels, I am able to judge of the merits and demerits of each kind, and I have now no hesitation in saying that the introduction of the cast iron disc-wheel (as made in America) on any railway line would effect a great economy. The general impression in England is, that the cast iron wheel is not safe at high speeds, and that the wrought iron wheel *is* safe. In answer to this, I would say, that the cast iron wheel is used often at high speed on the rough roads, and in the severe climate of the Northern States and in Canada, without any accidents happening from them. I will give a large reward to any one who will produce a record of a single accident having happened from the use of such wheels as I have used and now recommend. I have traveled many thousand miles by rail in the United States, often over very rough tracks, often at speeds over fifty miles an hour, often when the temperature was below zero, (Fahr.,) and I have never been in a train where there was a broken wheel, or have I ever seen a broken wheel in a carriage on one of our railways. In opposition to this, I would state that three winters since, I recollect seeing in the English papers accounts of several severe accidents happening in England, from broken wheels during some very severe cold weather, and that there were various comments on the causes of these accidents, all of which led me to believe at the time that the wrought iron wheel was not as safe as the cast iron. As to the life of the wheel, I would say, that the cast iron wheel will run over one hundred thousand miles; that many have run over one hundred and fifty thousand miles; that there were wheels in the International Exhibition of 1862 that had run on one of the Canadian railways one hundred and sixty thousand miles: that from an official report of the Erie Railway, now before me, I find that the lowest average life was thirty-four and three-quarter months, and as they estimate their carriage mileage at over four thousand miles a month, the run of these wheels was over one hundred and thirty-nine thousand miles. The English wrought iron wheel is undoubtedly a good and true wheel when first made; but, being of soft material, it wears rapidly, and has to be turned true in a lathe, (after running twenty-five thousand to thirty thousand miles,) at a cost about equal to recasting a cast iron wheel. A wrought iron wheel will stand two turnings and sometimes three. The 'tread' of the cast iron wheel being chilled, and being harder than the best tempered steel, wears very slowly. I would mention, that while in St. Petersburg, a few

weeks since, the manager of the Moscow Railway told me, that they had tried every class of wheels, and found none to stand the roughness of that road and the severity of that climate but the cast iron chilled disc-wheel; and yet on examining the wheels they had in use, made by themselves of Swedish iron, I found them very inferior to the wheels I now propose to introduce here. They also told me at St. Petersburg, that they had last winter tried twenty of the German steel wheels, and broke five of them during the winter.

"I would mention that the merits of the cast iron wheel, when compared with the wrought iron, are greater and more strikingly visible on railways running in mountainous countries where the curves are sharp and frequent, and where the gradients are steep, requiring the use of the brakes the whole length of the descending gradients. These wheels, if once introduced on the mountain roads of India, will never be abandoned. I say this on the strength of their having been adopted on every railway where they have been tried.

"I will not copy any portion of the mass of evidence which I have before me, in letters from resident engineers and managers of railways in the United States, in reference to the merits of the cast iron chilled wheel, but enclose to you a copy of a letter from Alexander M. Ross, who was the English engineer of the Grand Trunk Railway in Canada, knowing that such testimony is all that would be required by any man who will allow himself to investigate the truth of a subject. With such evidence, it will be hard for any one to doubt the merits of the cast iron wheel. * * * * * * Messrs. Anthony Gibbs & Sons, of London, who are the chief proprietors of the Lima railways of Peru, can also tell you about these wheels, as I have recently sent to their railways a new set of cast iron wheels to take the place of the wrought iron wheels now in use there on their old carriages. Their American carriages had cast iron wheels, which have been running since 1858. The cast iron wheels on the Arica and Tacno Railway, in Peru, have been running since 1855. I am told by Mr. John Higan, of 11 New Broad Street, that there has not been any new wheels sent to that road since I finished it in 1856, yet those wheels were not in any way equal to the best wheels now in use. Last week I had one of these cast iron wheels broken at the Bow Station of the North London Railway in the presence of some engineers. The sledges used were of twenty-eight pounds each. Three hundred and twenty blows (many of which were with two hammers) were struck before the stout smiths engaged in the work could break out a piece; as many more blows were struck before they broke the wheel to pieces, and then being unable to break the boss or centre, it was placed under a steam hammer of great power and destroyed."

This is very strong evidence, and must go far towards convincing those abroad of what we on this side of the Atlantic know so well.

Mechanics, Physics and Chemistry.

LECTURES ON VENTILATION.

Delivered before the Franklin Institute, by L. W. LEEDS, Esq.

LECTURE I.

PHILADELPHIA is one of the healthiest cities in the United States, and, in proportion to the number of its inhabitants, few more healthy cities exist in the world.

This is not owing especially to its mere healthy situation, but should be attributed, in a great measure, to the accidental superiority of the ventilation of a large proportion of its dwelling-houses.

Notwithstanding this comparative excellence, the theory of ventilation is not so thoroughly understood, nor is the practice so perfect, even in this city, that no advantage can be gained by further knowledge upon this subject.

Far from it. From the very best information we can command, and with the most accurate statistics at our disposal, we are forced to the conclusion that about forty per cent. of all the deaths that are constantly occurring are due to the influence of foul air.

The Registrar of Records of New York gives nearly half the deaths in that city as resulting from this cause.

The deaths in this city for 1865, according to the report of the Board of Health, were seventeen thousand one hundred and sixty-nine; the average age of those who died was between twenty-three and twenty-four years. It ought to have been twice that, as shown by some districts in the city and also in the country, where the houses are so arranged that they frequently have good ventilation.

Taking the deaths caused by foul air at a very low estimate, say forty per cent. of the whole, (the per centage from that cause is not so great as in New York,) we have six thousand eight hundred and sixty-eight deaths in this city, caused alone by impure air, in one year.

It is estimated by physicians that there are from twenty-five to thirty days of sickness to every death occurring; there would therefore be something like two hundred thousand days of sickness annually as an effect of foul air.

We all know how very expensive sickness is, but few persons realize

the enormous aggregate expense of unnecessary sickness in a city like Philadelphia.*

This subject has awakened much interest in Europe of late years, and has led to the expenditure of immense sums of money, for the purpose of improving the sanitary condition of their cities.

Dr. Hutchinson estimated the loss to the city of London, growing out of preventable deaths and sickness, at twenty millions of dollars annually, and Mr. Mansfield estimates the loss from this cause to the United Kingdom at two hundred and fifty millions of dollars.

In the single State of Massachusetts, an estimate exhibits an annual loss at over sixty millions of dollars by the premature death of persons over fifteen years of age.

It is estimated that a few only of the principal items of expense incurred by preventable sickness in the city of New York amounts to over five millions of dollars annually.

And if it is thought that Philadelphia is exempt from such enormous unnecessary expense, just glance at the report of the Board of Health for last year and see how the deaths from disease of the lungs largely exceed those from any other disease.

Consumption is almost entirely the result of breathing impure air,—it is as preventable by the exclusive use of pure air as *mania potia* or drunkenness is by the exclusive use of pure water. And see, too, what slaughter among the innocents; over twenty-five per cent. of the whole deaths were under one year of age.

The infantile mortality is by many considered the most delicate sanitary test. But why does such an intelligent community as this so neglect its own interest?

They have listened to and satisfied the first imperative demands of nature—shelter from the elements and warmth,—and in doing this they have not brought into use that much higher order of intellect that can alone teach them how to supply, in connection with an agreeable warmth, an abundance of pure air in their otherwise air-tight houses.

I have been much interested in examining a large collection of tables of the analysis of air, which accompany a report to Congress, on "Warming and Ventilating the Capitol," prepared by Thomas U. Walter, Professor Henry and Dr. Wetherill. These tables were made by men of various nations, giving the results of their analysis of air

* I mean merely pecuniarily—in dollars and cents—the cost in physical pain and mental anxiety, of course, cannot be computed in dollars and cents.

taken from all manner of places, from great elevations on the mountains and in balloons, from the valleys, from the centre of the ocean, and from the middle of the continent; in cities and in the country, in winter and in summer, at night and in the day, and also the comparative analysis of the air *out of doors and in houses.* Believing that these would be of much interest and assistance to us in the investigation of the subject under consideration, I have had copies made of some of the most interesting.

These give the per centage of carbonic acid in the air as the test of the amount of impurities in it.

This is not an infallible test by any means—there are various other causes of deterioration. There is the exhaustion of the oxygen constantly occurring to support combustion and animal life; there are various other deleterious products of combustion and respiration besides carbonic acid. But, as carbonic acid is always found in certain known proportions in pure air, and is always formed in certain known quantities by respiration or combustion, it is considered by many to give a very fair indication of the condition of the atmosphere with reference to its influence on animal life or combustion.

I think one of the most valuable lessons to be learned by the study of these tables is the uniform purity of the external atmosphere all over the world, even in large cities.

This is strikingly illustrated in the case of the analysis of the air in the city of Manchester.

We have nothing in this country like that city, where two millions of tons of coal are burned annually, the smoke from which fills the air and stretches like a black cloud far into the country.

This added to the five hundred tons of carbonic acid thrown from the lungs of its animal life every day, are many times that amount, (some two thousand tons,) daily, pouring out from its forest of factory chimneys.

To this city were the labors of the "Health of Towns Commission" first directed, to see if they could not find in the air of its streets that mysterious influence that has caused such alarm throughout the civilized world, as the thoughtful and intelligent sanitarian sees one-half of all his fellow-citizens hurried to untimely graves.

They were dissappointed, and well might Dr. Smith exclaim, after the most thorough and careful investigations, "How insignificant are the works of art in contaminating that vast ocean of air that is constantly sweeping over the surface of the earth!" But do not be dis-

couraged: more recent investigations have discovered the whereabouts of this pestilential breath.

I have placed the table of Dr. Angus Smith's analysis of the air of Manchester at the head of the list, and have copied it complete, because it is the only table that I have examined of the analysis of the air of towns in Europe or North America, in which there occurs an amount of carbonic acid exceeding ten parts in ten thousand.

Here we see three such cases in the twenty-eight experiments, one ten, one twelve and one fifteen.

The average of the whole is also greater than in any other similar tables, being about seven and a half parts in ten thousand. This is certainly quite a perceptible contamination, pure air containing four or four and a half parts in ten thousand. Yet considerable as this appears in this view, the additional amount of carbonic acid is only the proportion that would be added to the air, if unchanged, of a room fifteen feet square and ten feet high, by a father, mother and three children, with a gas-light, in seven minutes.

And this, probably, is the highest average contamination that is produced by artificial means upon the air of any city in the world.

There are, of course, great natural causes which affect the air of whole countries, such as the decomposition of great masses of vegetable matter similar to that occurring on the low, flat lands along rivers, especially where they overflow their banks, like the Ohio and Mississippi. The best system of ventilation, as applicable to this kind of foul air, is to keep as far out of its reach as possible.

The other tables giving the analysis of the air of London, Paris, Madrid, Geneva, Bolton, England, at various elevations on the mountains, on the Atlantic Ocean, Washington City and various other places, are interesting only because they show so great a uniformity in the carbonic acid, seldom exceeding six parts to the ten thousand, and seldom under four.

But now let us look upon the other side of the room. Here we have tables giving the "carbonic acid in houses." Here we will find very different results. But the first is a green-house, in that there is no trace of carbonic acid in the evening and scarcely a trace in the morning. Plants, you know, absorb the carbonic acid, and give off oxygen, while animals absorb the oxygen and give off carbonic acid, thus keeping up the equilibrium in nature, as is so beautifully shown in the aquarium. Plants are generally supposed to give off carbonic acid at night, but it must be in very small quantities.

I consider them very conducive to health in a living-room, morally and physically.

But this want of carbonic acid does not last long.

The next is M. Dumas' lecture-room. At commencement of lecture 42·5, and at close of lecture 67 parts in ten thousand.

Now, I think we are on the right track for discovering that mysterious poison that has carried so many of our friends to their graves, even in the very prime of life.

Here we have dormitories, 52; do., 37; asylum, 17; school-room, 30; do., 56; Chamber of Deputies, 16; Opera Comique, parterre, 15; do., ceiling, 28; stable, 7; do., 14; hospital, Madrid, 30; do., do., 43; air of bed-room on rising in the morning, 48; the same after being ventilated two hours, 16; railroad car, 34; workshop, Munich, 19; full room, do., 22; lecture-room, 32; beer-saloon, 49; and, worst of all, is a well-filled school-room, 72 parts of carbonic acid in 10,000.

That, I think, is enough. Here we have the solution of the whole mystery.

It is not in the external atmosphere that we must look for the greatest impurities, but it is in our own houses that the blighting, withering curse of foul air is to be found. We are thus led to the conclusion that *our own breath is our greatest enemy.*

The "Health of Towns Commission," in their investigations, after examining various trades, where the employees were confined mostly in houses, and having left the scavengers to the last, expecting to find a rich harvest of mortality among them, were much surprised to find them more healthy than many very clean occupations, but which were conducted in houses instead of in the open air. I have not the statistics before me, but I should not be surprised to learn that that singular race of beings that live in the sewers of Paris were as healthy, if not even more so, than the operatives of some of those exquisitely beautiful, clean, air-tight factories of New England.

There was quite an account made a few years ago of the wonderful cures of consumption that had been performed by the patient being removed to the stable where he could be in close proximity to the cow, and I have no doubt many consumptive patients would find great benefit by such a course of treatment, not that there is any virtue in the smell of the cow, but that the air of the cow-stable would be nearer pure than that of their own chamber.

Many go or send their families to the country in summer to get fresh air. Some go to the sea-side, others to the mountains; but there en-

sues a greater change in a few minutes in a close bed-room by being occupied by a family than there is difference between the external air of any city and that of the country.

The reason why cities are so much more unhealthy than the country, is not because the air in the street is so much more impure, but because the houses are so built together that this vast ocean of air cannot get at and through them to purify them as it does in the houses in the country, and the reason why Philadelphia is so much more healthy than its neighbor, New York, is because the houses here are built more like those of the country, so that the air can sweep all around them, and sometimes through them.

I therefore believe, that a family living in the filthiest street in our city, if they were careful to have a constant current of air from that street, filthy as it was, passing through the house at all times, night and day, would be more healthy, other things being equal, than a family spending their winters in the finest house, if kept air-tight, in the healthiest location in the city and their summer in the country, especially if they were always careful to exclude the *night air* from their bed-rooms.

I say "night air;"—there is, unfortunately, an unnecessary prejudice against what is termed night air, which means, I suppose, fresh external air from the dark.

To show that this is not a new idea, I will read a few lines from the writings of a very accurate reasoner and an eminently practical mechanic and philosopher, one who I consider even now one of the very best authorities upon the subject of heating and ventilation. I mean the illustrious man after whom this Institute was named, Benjamin Franklin.

In his letter to Dr. Ingenhaus, physician to the Emperor, at Vienna, he says: * * * * "for some are as much afraid of fresh air as persons in the hydrophobia are of fresh water. I myself had formerly this prejudice,—this *aerophobia*, as I now account it,—and dreading the supposed dangerous effects of cool air, I considered it an enemy, and closed with extreme care every crevice in the rooms I inhabited. Experience has convinced me of my error. I now look upon fresh air as a friend: I even sleep with an open window. I am persuaded that no common air from without is so unwholesome as the air within a close room that has been often breathed and not changed. Moist air, too, which I formerly thought pernicious, gives me now no apprehensions; for considering that no dampness of air applied to the outside of my

skin can be equal to what is applied to and touches it within, my whole body being full of moisture, and finding I can lie two hours in a bath twice a week, covered with water, which certainly is much damper than any air can be, and this for years together, without catching cold, or being in any other manner disordered by it, I no longer dread mere moisture, either in air, or in sheets or shirts; and I find it of importance to the happiness of life, the being freed from vain terrors, especially of objects that we are every day exposed inevitably to meet with.

"You physicians have of late happily discovered, after a contrary opinion had prevailed some ages, that fresh and cool air does good to persons in the small-pox and other fevers. It is to be hoped, that in another century or two we may all find out that it is not bad even for people in health. And as to moist air, here I am at this present writing in a ship with above forty persons, who have had no other but moist air to breathe for six weeks past; everything we touch is damp, and nothing dries, yet we are all as healthy as we should be on the mountains of Switzerland, where inhabitants are not more so than those of Bermuda or St. Helena, islands on whose rocks the waves are dashed into millions of particles, which fill the air with damp, but produce no diseases, the moisture being pure, unmixed with the poisonous vapors arising from putrid marshes and stagnant pools, in which many insects die and corrupt the water. These places only, in my opinion, (which, however, I submit to yours,) afford unwholesome air; and that it is not the mere water contained in damp air, but the volatile particles of corrupted animal matter mixed with that water, which renders such air pernicious to those who breathe it; and I imagine it a cause of the same kind that renders the air in close rooms, where the perspirable matter is breathed over and over again by a number of assembled people, so hurtful to health.

"After being in such a situation many people find themselves affected by that *febricula*, which the English alone call a *cold*, and, perhaps, from that name, imagine they have caught the malady by *going out* of the room, when it was, in fact, by being in it."

Now, to show that his hopes have not yet been fully realized, although one century has nearly closed since he wrote what I have just read, and this unnecessary and unfortunate prejudice against night air still prevails extensively, I will read a few lines from the highest public medical authority in this city. It is the instructions of the Board of Health for the prevention of cholera for 1866:

ARTICLE—"VENTILATION."

"Your premises, particularly sleeping apartments and cellars, should be thoroughly ventilated. Ventilation is no less a purifier than water.

"It cleanses by oxidizing and drying. Keep your houses open and your windows hoisted during the day in good weather, and from ten o'clock until four in the afternoon, that they may have the full benefit of sunlight and free circulation of pure air. *During the remaining hours of the day, and through the night, keep the windows closed.* When the weather is cool or rainy, be sure to keep a fire in the house, in order to prevent dampness, or in sparsely settled neighborhoods, or in the suburbs of the city, have a fire in the house the entire season."

On page 9 we read: "Be careful to dress comfortably for the season, *avoid the night air* as much as possible, and when thus exposed, put on an extra garment and do not go into *the night air* when in a state of perspiration."

Thus, while recognizing the great value and importance of ventilation in a general way, they give the most definite instructions for thoroughly and most effectually preventing it, because it is at night, especially when we are asleep and *cannot move from the air, that the air ought to be moved from us.*

The frequent recommendations to avoid "night air" are simply recommendations to smother ourselves to death, because the foul, poisonous exhalations from our lungs cannot be removed from our chambers without being replaced by night air; there is no other fresh air at night but night air.

The recommendation to build a fire in the house on cool days, and in low marshy districts every day in the year, is an excellent one.

The recommendation to dress warmly and to avoid checking a perspiration suddenly, are valuable suggestions and too much attention cannot be paid to them.

But they are of equally great importance in reference to day air as to night air.

To shelter himself from the sudden change of temperature after sundown is an animal instinct, and a very necessary one, which is strongly implanted in man and beast alike.

The harm comes from the fact of so intelligent and intellectual a body as the Board of Health of Philadelphia encouraging the accomplishment of this very desirable object, by thwarting that great universal law of our Creator, the ceaseless agitation of the air by which

it purifies itself, (and by which perversion of nature's laws millions are already being killed unnecessarily every year,) instead of their encouraging its accomplishment in that much more healthy and rational way by adding more clothing or more fuel to the fire, and still continuing to breathe the pure air at night as well as in the day-time.

I have practised for many years sleeping with my windows open every night, summer and winter, allowing the unobstructed breeze to flow across my bed, to the great improvement of my health and strength.

There is no objection in a well ventilated room to having a fire if desired. A small room with a hot stove or open fire and the windows open, is much more wholesome than a large air-tight room freezing cold.

(To be continued.)

From the London Chemical News, No. 348.

(Continued from Vol. LII., page 229.)

SUPPOSED NATURE OF AIR PRIOR TO THE DISCOVERY OF OXYGEN.

By GEORGE F. RODWELL, F.C.S.

XV. JOHN MAYOW.—We have mentioned in the preceding paper that, from an early period in the history of physical thought, the scientific had admitted a relationship between the air and nitre, undefined, indeed, and unintelligible, yet too palpable to be denied. The flexity of this theory is proved by the fact that it was maintained by philosophers who differed in the generality of their views, and who were more wont to oppose each other than to agree even upon the most trivial point. In this instance they acknowledged the main fact, and only differed as to the precise nature of the relationship. Towards the middle of the seventeenth century the theory was established upon a firmer basis; it was inevitable, in a period when the physical sciences began to engage the serious attention of mankind, when scientific literature was on the increase and new instruments and modes of research were perpetually invented, while experimenters were arising on all sides, it was inevitable, we say, that the value of a theory which had endured for so long a time should be critically examined.

We have before mentioned that Robert Hooke was the first who threw much light upon the subject, by asserting as part of his theory of combustion* that there is "a substance inherent and mixed with the air which is like, if not the very same, with that which is fixed in saltpetre,"

* For an account of this theory see the tenth of these papers, *Chemical News* for February 17th, 1865.

and which is the "dissolvent" of combustible bodies. Unfortunately, the experiments upon which this theory was founded were never published, and we are thus left completely in the dark as to their nature and the extent to which we may rely upon them.

Hooke's theory of combustion was eagerly embraced by an Oxford student named John Mayow,* who in 1674 published a volume of essays,† in which he extended the theory, and detailed a number of very ingenious experiments in support of it.

Mayow commences his treatise by affirming that nitre consists of an alkaline salt united with an acid, which latter derives its active principle from the air. This principle produces combustion, and is the cause of acidity. Mayow calls it "*fire-air*," "*nitre-air*," and "*nitro-aërial spirit*," indiscriminately. It will perhaps be most convenient for us to speak of it throughout, as *nitre-air*. The atmosphere does not consist entirely of nitre-air, as is proved by the fact that when a candle is allowed to burn in a jar of air standing over water, a portion only of the air is consumed. Nitre-air is not itself combustible, but it causes combustible bodies to be consumed by producing a fermentation (*fermentatio*), for combustion is a very destructive kind of fermentation. Nitre contains no combustible matter, as may be proved by throwing a small quantity into a red-hot crucible, when it will be observed that ignition will not take place until some combustible body has been added. Nitre-air is condensed in large quantities in nitre. It is for this reason that combustible bodies mixed with it can burn in vacuo, or under water. But although the nitre-air is all contained in the acid of nitre, the latter cannot inflame combustible bodies when poured upon them, because the nitre-air particles are surrounded by particles of water. It is needless to remark here, that Mayow was unacquainted with the now familiar experiment of pouring turpentine into nitric acid.

Mayow attributes the increase of weight experienced by antimony during calcination, to the fixation of nitre-air, a supposition borne out by the fact that he procured a substance exactly resembling calx of antimony, by treating the metal with nitric acid, and evaporating. Vitriol of iron is produced from marcasite by nitre-air forming an acid with the sulphur of the mineral, which acid unites with the iron. Rust of iron is formed by the union of nitre-air with iron. Vitriol of iron is a perfect vitriol, while rust is an imperfect vitriol.

Nitre-air is present in all acids; sulphuric acid is produced by the union of nitre-air particles with sulphur; wines are changed into vinegar by the assimilation of nitre-air from the atmosphere. Nitre-air is

---

* Born 1645, died 1679.

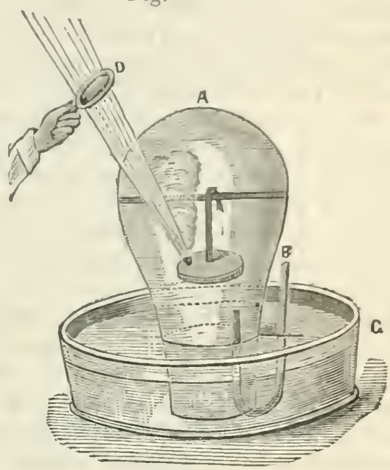
† This work is entitled "Tractatus quinque Medico-physici. Quorum primus agit de Sal-nitro et spiritu nitro-aëreo. Secundus de Respiratione. Tertius de Respiratione fœtus in utero et ovo. Quartus de Motu Musculari et spiritibus animalibus. Ultimus de Rachitide. Studio Joh. Mayow, LL.D. et Medici, nec non Coll. Omn. Anim. in Univ. Oxon. Socii.—Oxonii, 1674." The Vice-Chancellor's order for printing the work is dated July 17th, 1673. It was therefore completed in Mayow's twenty-ninth year. The first edition is very scarce, but the 1681 edition printed at the Hague, is comparatively common. The treatise on respiration was first published in 1668, in Mayow's twenty-third year.

also the cause of fermentation and of putrefaction; hence bodies covered with butter or oil, or otherwise kept out of contact with the atmosphere, do not putrefy.

Mayow treats at some length of the analogy between respiration and combustion, and we are here introduced to the first experiments in pneumatic chemistry.

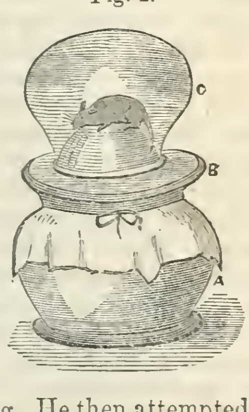
A piece of camphor dipped in melted sulphur was supported in a glass jar, A, Fig. 1, standing over water. As stoppered air jars were not known at the time, (from the simple fact that they had hitherto been unneeded,) Mayow was obliged to adopt some special means for rendering the height of the water inside and outside the jar the same. He effected this by introducing a small siphon, B, which was placed in the position shown in the figure during the depression of the jar into the water vessel, C, and was afterwards withdrawn. The camphor was then fired by the lens, D. When it was extinguished, and the water had ceased to rise into the jar, he attempted to fire the remaining camphor, but without success.

Fig. 1.



In order to prove that air is diminished in volume by breathing, Mayow procured an open glass jar, A, Fig. 2, and tied firmly over the opening a piece of bladder, B, upon which he inverted a cupping-glass, C, containing a mouse. The edges of the cupping-glass were pressed firmly upon the bladder, so as to prevent communication with the outer air. It was soon observed that the bladder was pressed up into the cupping-glass, because, says Mayow, an inequality of pressure has been produced by the diminution of the bulk of air within the cupping-glass caused by the breathing of the mouse.

Fig. 2.



The experiment was modified by placing the mouse in a vessel inverted over water, when it was found that water rose into the vessel as the animal continued to breathe, and by roughly graduating the vessel Mayow calculated that the air was diminished one-fourteenth by breathing. He then attempted to ignite combustible matter in a closed vessel in which an animal had been suffocated, but without success, a proof that air which is unfit to support life is also unfit to support combustion. It was thus conclusively proved, that during the processes of respiration and combustion there

is a something abstracted from the air necessary for the maintenance of those processes, and that the residue is unfit to support either life or combustion.

A mouse was placed in a jar of air inverted over water, together with a lighted candle; the latter speedily went out, and the mouse lived only half the time that a mouse lived in the same bulk of air when the candle was not present; hence, argues Mayow, respiration and combustion both deprive the air of the same kind of matter, viz: of nitre-air.

Air deprived of its nitre-air particles is lighter than atmospheric air, because a mouse placed near the top of a closed vessel of air dies sooner than when it is placed near the bottom of the vessel; and if we take two mice, and place one at the top and the other at the bottom of a closed vessel, that at the top will die before the other.

Mayow made several experiments to determine whether air can be generated *de novo*, and the first artificially produced gas which he examined, in order to ascertain whether it was atmospheric air, was hydrogen, which, as we have seen, was procured some years previously by Boyle. In order to determine whether this gas was capable of as much expansion as air, Mayow made the following experiment: Hydrogen was procured by inverting a vessel of water over small pieces of iron placed in a vessel containing dilute sulphuric acid, and some of the gas was transferred* to a graduated tube in sufficient quantity to occupy the space of one division. The tube, with its lower end dipping beneath the surface of water, was then placed under an air-pump receiver, which was exhausted as completely as possible. The gas expanded to about two hundred times its original volume, and atmospheric air was not found to expand to a greater extent. It was thus ascertained that this property is common to both kinds of air; but the experiment proves nothing as to the nature of the generated air, because Mayow had previously found that air in which a candle had been extinguished was capable of expanding to a similar extent.

In order to ascertain whether air procured from iron filings and dilute sulphuric acid was respirable, Mayow placed a mouse in an inverted vessel partially filled with air, and noted the length of time before it died. The same volume of air was then passed into a similar vessel, a mouse introduced, and a large volume of hydrogen transferred to the vessel; but the mouse lived scarcely longer than its predecessor, whereas if the new air were respirable it ought to have lived two or three times longer. Mayow attributes the fact of its living rather longer to the dilution of the nitre-air particles by the introduced gas, and the consequent prevention of their rapid consumption.

We have seen that almost every writer on the nature of the air has touched upon the subject of respiration. In the first of these papers we have the theories of Plato and Aristotle: in almost the last that of Boyle. It was natural that a question so intimately connected with life

* The gas was transferred from one vessel to another by the method adopted in the present day, which, we believe, was devised by Mayow, since we have seen no mention of it in any work earlier than the treatise we are considering.

should from the earliest ages engage the attention of mankind. Indeed, almost the only evidence which the ancients possessed of the existence of air was derived from its necessity to animal life. From the continued observation that the cessation of breathing was the cessation of life, the belief became prevalent that the soul passed from the body with the last expiration of air; hence the expressions "*efflare animam*," "*exhalare animam*," "*expirare animam.*" Again, πνεῦμα, *spiritus*, and *anima*, have each the triple meaning of *soul*, *breath* and *wind*, and Mr. Hodges informs me that in Hebrew the word גוע means "*efflare animam;*" also that רוח has the three meanings of *soul*, *breath* and *wind*. The close connection existing between the function of respiration and the principle of life being thus clearly recognized and acknowledged, we cannot wonder that a number of theories were promulgated in every age to account for the precise nature of that function.

The more important of these theories were combated by Mayow in a treatise "On Respiration," which was far in advance of those of all previous writers on the subject. He had proved that only the nitre-air particles of the air are necessary for the support of life, and he contends that these particles are absorbed by the blood, whilst the rest of the air is rejected. The absorption of nitre-air produces heat in the body, and it is the object of respiration to produce animal heat, which arises from a kind of fermentation caused by the union of nitre-air with the combustible particles present in the blood. In like manner muscular motion is caused by nitre-air uniting with combustible particles in the structure of the muscle. During violent motion we breathe quickly, because nitre-air is required in greater quantity than when we are at rest, to supply the greater amount of muscular motion called into activity; and as combustible particles are removed very rapidly from the body under such circumstances, we require food containing a large quantity of such particles before and after violent action. When the chest is expanded, air, by its elastic force, rushes into the lungs, which are composed of a number of minute bladder-shaped membranes, through which nitre-air passes to the blood.

Mayow's work is remarkable in several respects. In it he conclusively proved that respiration and combustion are analogous processes. He upset the four-element theory by demonstrating the compound nature of air, and he recognized oxygen and nitrogen as clearly and almost as notably as they were recognized a hundred years later—the one the supporter of life and combustion, the principle of acidity, and the cause of fermentation and putrefaction, heavier than atmospheric air; the other incapable of supporting life or combustion, and lighter than atmospheric air. We find, moreover, in this work the dawn of the idea of chemical affinity, in the "fermentation" which he speaks of as taking place between nitre-air and combustible particles, and as tending to the production or destruction of things. Mayow even employs some of the terms in general use in the present day. Thus he speaks of "*affinatas*" existing between acids and earthy substances, and uses the words "*combinetur*" and "*combinentur*" in speaking of the "*congressus*" of different substances.

The treatise is characterized by much clear and condensed thought, well-sustained argument and accurate reasoning. Moreover, we seldom meet with instances of too hasty generalization, always the dominant source of error in the early development of a science. We further observe a great advance towards that exact and discriminative mode of thought which is necessary for the investigation of chemical phenomena. The period in which Mayow wrote was, as regards chemistry, a period of transition; there was as yet no work on scientific chemistry, yet Mayow's treatise approached more nearly to such a work than that of any of his predecessors. The works of previous writers in this direction belonged to one of the three following classes: They were either chemico-metallurgic, chemico-medical, or alchemical treatises, or they partook of the nature of all three. The publication of works on alchemy was fast waning before the advances of the new philosophy; for a superstition retreated, and as men began to devote their energies to the legitimate investigation of Nature, a false and chimerical art must of necessity cease to find votaries. Mayow was the first to discuss the intimate nature of an intangible body. Other writers had treated of the air as a whole, but no one had endeavored to ascertain the nature of its internal constitution, or to determine why it produces certain changes in surrounding bodies, upon what these changes depend, and the nature of the constituent or constituents of the air producing them. The old dogma of the elemental nature of the air was received as an absolute truth, although entirely unproven. It was thought that a theory which had been received since the earliest ages must of necessity be correct, and no attempt was made to disprove it.

We see from the above that it was the investigation of the nature of nitre which led to the knowledge of the constitution of the air. Mayow remarks at the commencement of his treatise, that so much had been written about nitre that it would appear "*ut sal hoc admirablile non minus in philosophia, quam bello, strepitus ederet; omniaque sonitu suo impleret.* "And, indeed, from the time of Mayow, nitre *has* made almost as much noise in philosophy as in war. If, on the one side, it has subdued unruly factions, has it not, on the other, destroyed obstinate theories? If it has dispersed turbulent assemblies, has it not dissociated the most firmly united compounds? New dynasties have arisen by its aid, alike in the realms of the earth and of philosophy. The greatest of the philosophic dynasties which has thus arisen was established by Mayow, and it has endured almost unchanged to the present day, a monument alike to his ingenuity, his perseverance and his scientific ardor.

(To be continued.)

(Continued from page 32.)

BALL AND SOCKET JOURNAL-BEARINGS.

By Coleman Sellers.

When journals are to be supported by bearing, attach to wooden frames, or to any frames which are likely to bend or twist, or when the

shaft between the journals, even in a rigid frame, is liable to be bent or sprung in working, there the proper bearing is one that can accomodate itself to the varying position of the shaft, and insure an uniform pressure over the whole surface, as, for example, in the line shafting for conveying and distributing power. Such lines are usually suspended from the girders or ceiling of the room, or attached by brackets to posts, &c., and are liable to be thrown out of line by the settling of the floors from loads, and other causes.

What is now known as the ball and socket hanger for this purpose, is a species of journal-bearing or box formed with a spherical surface in the centre of each half of the journal-bearing, so made that the centre of the sphere thus formed coincides with the axis of the journal and is equi-distant from each end of the box. This bearing is then held between concave surfaces, like a ball-joint, and while it is held central its ends are still free to vibrate a short distance in any direction, so that the journal in rotating in the box, controls the positions of the bearing so far as its general surface is concerned, but the bearing holds the journals in line. Hangers made with ball and socket-bearings of this kind are also provided with means of adjustment, so that settling of the buildings, &c., having thrown the shafting out of line, the bearings can be reclined without disturbing the attachment to the building.

In using cast iron for journal-bearings of this kind, it has been found that when the bearing is made four times as long as the diameter of the journal, a sufficient surface is obtained. This rule holds good up to say $4\frac{1}{2}$ inches diameter of journal. For longer shafts it is customary to somewhat shorten the bearing, thus making 5 inch journal 18 inches long; $5\frac{1}{2}$ inch and 6 inch, 20 inches long; 7 inch, 22 inches long and 8 inch 24 inches long.

The distance from centre to centre of the hangers, of line shafting, should be, if possible, uniform, and practice has shown that to use the least amount of material to do a given work, this distance should be for $1\frac{3}{4}$ inch and 2 inch shaft, 7 feet and not over 8 feet, and for larger sizes, up to $3\frac{1}{2}$ or 4 inches, 8 feet and not over 9. The size of shaft to do a given amount of work, *i.e.*, receive and distribute a given amount of power, can be determined very conveniently by a table published at page 175, *Pocket-book of Mechanics*, by J. W. Nystrom. In this the number of revolutions of wrought iron shafts per minute being given in the top row of figuring, and the horse-power at the side column. The table shows size of shaft required for each case. Thus, for 50 horse-power, a shaft 5·38 inches diameter will be required, if the shaft makes only 40 revolutions per minute, but if it is to make 120

revolutions per minute, the proper sized shaft would be 3·73 inches. Now, this holds only for the first shaft, or that to which the power is applied from the engine, and in continuing the line and distributing the power, the shaft may gradually decrease in size, the rate of such decrease depending upon the nature of the work done at various points. As an example of the advantages of cast iron journal-bearing arranged in this manner, I may cite the case of a 24 inch circular saw, having its mandril journals fitted with solid cast iron ball and socket-bearings, *i.e*, with a box not made in halves, and therefore not capable of being closed up to compensate for wear, having been in daily use for over fifteen years and yet showing no appreciable wear.

(To be continued.)

EDUCATIONAL

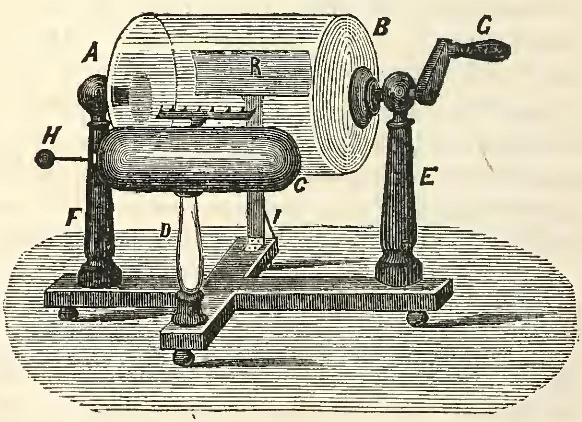
(Continued from page 54.)

LECTURES ON ELECTRICITY AND LIGHT.

Delivered before the Franklin Institute, by PROF. HENRY MORTON, PH.D.

HAVING acquired a general idea of the actions of the electric fluids in relation to the friction of dissimilar bodies, by the means already

Fig. 4.



described, we are in condition to understand the operation of those instruments by which these fluids are separated in a convenient man-

ner and in large quantities. Such instruments are known by the general names of Electrical Machines. The first and simplest of these is the Cylinder Machine. The form and structure of this apparatus is so familiar to all, that we will devote but a few words to its description, and then draw attention to a few points, of importance in securing from it the best effect, which are sometimes overlooked. A cylinder of glass, A B, which does not contain either lead or soda, is mounted on an axle of dry wood, or is supported by wooden caps, secured independently at either end. These caps are supported in journals, and to one a winch, G, is attached, with a handle for turning. A rubber of soft leather, R, is so placed as to press upon the cylinder as it rotates, and on the opposite side is arranged a large rounded conductor, H C, on an insulated support, D, and provided with a comb, or row of sharp metallic points, directed towards, and approaching closely to, the glass cylinder. It is hardly necessary to add that the electricities are separated by the friction of the glass and rubber, and that the positive fluid, going round with the glass, is taken off by the sharp points, and accumulated in the insulated body, which is called the prime conductor. To obtain the best effects from this machine, the rubber should be a good conductor, and in connection with the ground, so as to have an unlimited supply of positive fluid for the glass. If, therefore, the rubber is made of folded flannel, horse hair, or the like, covered with silk, strips of tinfoil should be inserted within it, and connected with the wooden upright which supports it. A silk flap or apron should also be attached to the upper edge of the rubber, and pass over the cylinder, reaching nearly to the collecting points on the other side. In this case, the cylinder is, of course, so turned that its upper surface moves from the rubber to the points. Upon the face of the rubber should be spread some electrical amalgam or some Mosaic gold, (bisulphide of tin.) The former is prepared by melting two parts of tin in a crucible, and to this, first adding three parts of zinc by degrees, and lastly, four parts of mercury, with constant stirring, then pouring into water to granulate. Or, one part of zinc, melted, and added to four parts of mercury in a mortar, and rubbed with the pestle until cold, is as efficient. Either should be pulverized in a mortar before use, and spread over the cushion, previously greased.

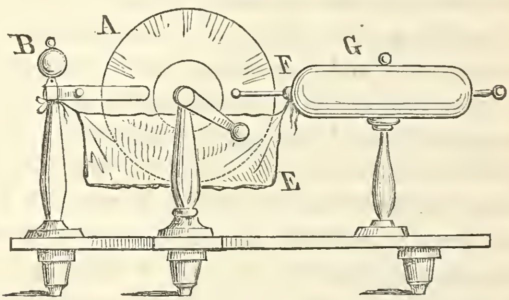
In place of either of the foregoing recipes, I have obtained an excellent effect with less trouble by dissolving scraps of tinfoil in a drop of mercury, until the mixture was semi-solid, and applying this with tallow, as before.

Mosaic gold is, however, decidedly preferable, on all accounts, as it can be applied without grease, does not scratch the glass and may be procured from those dealing in general chemicals, as it keeps without deteriorating.

The cushion or rubber is sometimes supported on a glass upright, for the purpose of obtaining negative electricity from it. (In this case the prime conductor should be connected with the ground.) But this arrangement is not to be recommended, as the cylinders are never perfectly true, and, in turning, produce an irregular strain, very likely to fracture the glass support. A wooden upright, hinged to the base and pressed against the cylinder by a stiff spring, I, is more reliable.

A more complete form of this instrument is that known as the "plate machine," represented in Fig. 5. In this case, a disk of plate glass, A, is supported by an axle on wooden uprights, and turned by

Fig. 5.



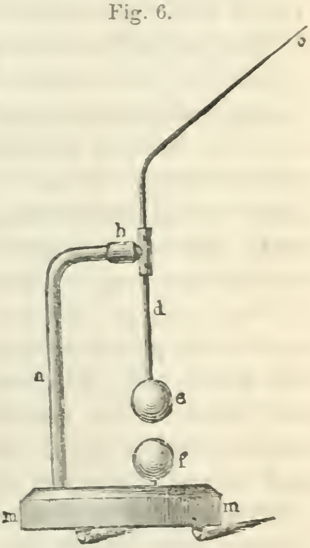
a handle. Rubbers are supported at B, on a glass upright, and are pressed by springs against the opposite surfaces, while prongs at F, passing around the plate, and provided with fine points on their inner sides, collect the positive fluid, and pass it into the prime conductor, G. The silk bag, E, prevents loss. In this, as in all like electrical apparatus, the parts intended to retain the fluids should be rounded; those to collect or to disperse it, sharp. The reason is obvious from a consideration of the fundamental properties already stated. "Particles of the same fluid repel each other." As a result of this, a sharp point connected with a charged conductor, affords a place from which particle after particle of the fluid may be easily pushed off, by the combined repulsion of the particles behind. Again, every transfer of electricity is a double action, as is indicated on page 54. When a positive spark passes from A to B, a negative one at the same instant goes from B to A. Thus, let A represent a positively charged body,

A | + + + + | and B a neutral one; then after a spark has passed

B | — + — + | from A to B, (as we generally express it,) the con-

dition of the two will be correctly indicated by A′ B′, A′ | — + + + | in which we see not only that a positive particle has B′ | + + — + | gone from A′ to B′, but that a negative one has gone in the opposite direction, *i.e.*, from B′ to A′. Thus, the absorption of electricity by a point, becomes synonymous with the discharge of the opposite kind, and will follow the same rule. Hence, a point will not only give off electric fluid easily, but will also, as before stated, readily absorb it, the two actions being in fact identical, though we separate them in our idea. Thus, to give off positive, is to take on negative fluid, and to give off negative, is to take up positive in turn. There are various ways in which the above action might be explained, but that just stated seems to us the most direct. The *fact* of this process may be easily shown as follows: Such an apparatus as that represented at Fig. 6 is prepared. It consists of a wooden block, *m m*, to which are attached a brass ball, *f*, and a glass rod, *a*. The glass rod supports a bent wire, *d*, terminating below in a brass ball, *e*, and above in a point, *c*.

Fig. 6.



The point of the wire is directed towards some charged body, such as the prime conductor of the machine, Fig. 4 or 5, when sparks will be seen to pass between *e* and *f*, showing that fluid is being absorbed by the point. If the point is directed towards a positively charged body, such as the prime conductor already mentioned, we shall see upon it (if it is in a dark room) a star or point of light, such as will appear on a point connected with the insulated rubber of the plate machine, Fig. 5, and therefore indicating the *escape* of *negative* fluid; but if the point is turned upon such a negative body as the rubber above mentioned, it will show a rush of light such as would be obtained from a point on the prime conductor, thus indicating an *escape* of *positive* fluid. The sparks between *e* and *f* would, however, be the same in either case, for, as already explained, it would be a double discharge in both instances; positive going down, and negative up, in the first case, negative down, and positive up in the second.

(To be continued.)

(Continued from page 58.)

THE MAGIC LANTERN

AS A MEANS OF DEMONSTRATION.

We concluded in our last article, the subject of oxygen manufacture, and will now consider the best means of preparing the other essential material for the production of a powerful lime light, namely, hydrogen.

Preparation of Hydrogen.

The simplest method of preparing this gas in large quantity, as regards apparatus, is to provide a common glass gallon bottle, with a cork penetrated by a single bent tube; to place in this a pound or two of mossy zinc (obtained by pouring melted zinc from the height of three or four feet into a bucket of water); to pour over this about a quart of diluted sulphuric acid, previously mixed and cooled (about one pint acid to four water); to insert the tubulated cork, and connect this outlet by a rubber tube, with a wash-bottle and gas bag, or other reservoir. When the action in the bottle has ceased, if more gas is needed, remove the cork and pour in a fresh quantity of diluted acid. Three or four additions will develop gas enough to fill a thirty by forty inch bag, (= thirty to forty gallons.)

Where the gas can be conveniently stored in sufficient bulk, we know of no plan more economical, efficient and convenient, than this, and with a relay of bottles (which cost but a trifle), a few minutes will suffice for the manufacture of all the hydrogen needed for a couple of hours' light. But two volumes of hydrogen being used to each volume of oxygen, the reservoir must in this case be bulky.

Where these facilities for storing large volumes of gas are not present, an excellent arrangement is that figured in cuts 3 and 4. This, which is called a hydrogen generator, consists of a copper bucket, B C, about ten inches in diameter and two feet high, in which is placed a pail full of water and a quart of sulphuric acid. The copper bell, A, which fits loosely in the bucket, is provided with a movable perforated tray, which is introduced sideways, and when turned square across, is supported on lugs riveted to the lower edge of the bell. This bell is filled with fragments of scrap zinc. This

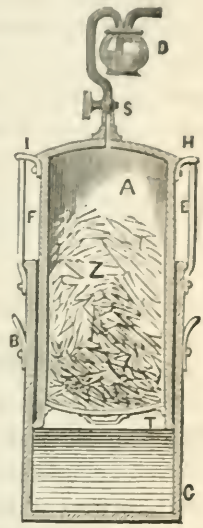
bell has also at its upper edge two lugs, I and H, which may rest on two iron rods, F E, attached to the bucket, as in the drawing, by which it is supported clear of the acid solution. A stop-cock, S, gives

Fig. 3.

opening to a tube and small wash-bottle, D.

This stop-cock being opened, and the bell lifted from the supporting rods and lowered into the bucket, the zinc soon enters the acid, and hydrogen is liberated in large quantity. When the stop-cock is closed, the gas accumulates in the bell, expels the acid, which, rising in the annular space around, soon floats the bell so as to clear the zinc from the liquid when the action ceases. One or two small holes should be made in the bell, about half an inch from its lower edge; otherwise, on suddenly shutting off the escape of gas, enough may be generated by the liquid adhering to the zinc, to cause large bubbles to escape under the edge. These rising violently in the space between the bell and bucket, splash the acid about. The small holes, however, allow the gas to escape in minute bubbles, which do no harm.

Fig. 4.



The acid and water should be mixed beforehand, and allowed to cool. It requires some time to get the air rinsed out of the generator, so that the hydrogen may be ignited at the jet. After use, if the acid is not exhausted, and it is desired to employ the apparatus soon again, the bell may be supported as before; and if the level of the liquid is adjusted a little above that indicated in Fig. 4, the bell will remain full of hydrogen, and will not need any fresh "blowing out." If not to be used in a day or two, it is the best economy to throw out the liquid, or empty it into a stone-ware jar, even if not exhausted, as the copper is much corroded when it stands in the liquid and is not in use.

An apparatus such as described with the charge mentioned, will run a single lantern for over five hours, or a double (*i.e.*, dissolving) lantern for three hours. It is best to keep the bell pretty full of

scrap zinc, say twenty pounds, which will, of course, outlast many charges of acid and water.

In place of the wash-bottle attached to the bell, the same one used in the preparation of oxygen (page 58) may be employed, care being taken to blow out the oxygen left in it, before igniting the gas.

Messrs. Queen & Co. substitute for the wash-bottle, a sponge placed in a conical chamber immediately below the stop-cock, with good effect.

(To be continued.)

Franklin Institute.

Proceedings of the Stated Monthly Meeting, February 20th, 1867.

The meeting was called to order with the President, Mr. J. Vaughan Merrick, in the chair.

The minutes of the last meeting were read and approved.

The Actuary presented the minutes of the Board of Managers, and reported that the Board had organized on the 9th of January, ult., by electing Messrs. Bloomfield H. Moore and Percival Roberts, Curators for the ensuing year, and appointing the following Standing Committees:

ON INSTRUCTION.

Henry Morton,
Wm. J. Horstmann,
Coleman Sellers,
Pliny E. Chase,
Robert E. Rogers.

ON ELECTIONS AND RESIGNATIONS.

O. Howard Wilson,
Henry G. Morris,
Henry Cartwright,
Samuel Wright,
Charles S. Close.

ON STOCKS AND FINANCES.

William Sellers,
Frederick Fraley,
James S. Whitney,
James Dougherty,
Washington Jones.

ON PUBLICATIONS.

Coleman Sellers,
Bloomfield H. Moore,
William B. Bement,
Samuel Sartain,
George Erety.

Donations to the Library were received from the Royal Geographical Society, and the Society of Arts, London, England; l'Ecole des Mines, la Société d'Encouragement pour l'Industrie Nationale, Paris; and la Société Industrie Nationale, Mulhouse, France;

K. K. Geologischen Reichsanstalt, K. K. Geographischen Gesellschaft, Neiderösterreichischen Gewerbe-Vereines, Vienna, Austria; the Literary and Historical Society, Quebec, Canada; the Institute of Natural Science, Halifax, Nova Scotia; the Commissioner of Agriculture, Washington; the American Philosophical Society, H. P. M. Birkinbine, Esq., John Rice, Esq., and Doctor Edward Parrish, Philadelphia.

The various Standing Committees reported their minutes.

The Special Committee on Experiments in Steam Expansion, reported progress.

The Committee on General Totten's letter, with respect to the establishment of a Government Bureau of Examination and Experiment, reported progress.

The Committee to collect material relating to the history of the Institute, reported progress.

The report of the Resident Secretary was then read.

(The editor would here state that he proposes to publish the substance of the Secretary's Report in future, under other forms and in other parts of the *Journal*, as by this means new matters will receive earlier notice, and need not be delayed in publication, by any reference to the times of meeting.)

After the conclusion of the Secretary's Report, new business being in order, the following preamble and resolutions were offered by Mr. William Sellers, and adopted by the meeting:

PREAMBLE AND RESOLUTIONS ADOPTED AT THE MEETING OF THE FRANKLIN INSTITUTE, HELD FEBRUARY 20, 1867.

Whereas, In pursuance of the Act of Assembly, approved May 7th, 1864, a committee of the City Councils of Philadelphia is now engaged in the preparation of an ordinance for the regulation and inspection of the steam-boilers used within the city limits; and whereas, the objects contemplated by the act aforesaid and the proposed ordinance, cannot but have a very important bearing upon the manufacturing industry of the city; and whereas, the subject is one in which the engineering profession is particularly interested, and the committee having, by circular, invited suggestions as to the best method of accomplishing the object in view; therefore

Resolved, That the Secretary of the Institute be requested to procure fifty copies of the proposed ordinance for distribution among the members of the Institute, and that special meetings, for the consideration of the same, shall be held ever Wednesday evening, at 8 o'clock, until the provisions of the proposed ordinance shall have been fully discussed, and changes that may seem requisite shall have been recommended by the Institute for the consideration of the committee and of Councils.

Resolved, That notice of the proposed meetings, with the objects thereof, shall be given in three daily papers of this city, and that a copy of this preamble and resolutions shall be sent to each member of the Committee on Law, Select and Common Councils, with an invitation to attend the proposed meetings.

The following Standing Committees were then appointed by the President:

ON THE LIBRARY.

John C. Browne,
Robert Briggs,
Charles Bullock,
Pliny E. Chase,
Samuel Hart,
Bloomfield H. Moore,
Henry G. Morris,
Henry Morton,
Percival Roberts,
Samuel Sartain.

ON ARTS AND MANUFACTURES.

Wm. Adamson,
John H. Cooper,
Charles E. Foster,
C. Eugene Meyer,
Jacob Naylor,
Hector Orr,
Wm. G. Rhoads,
James B. Sword,
John C. Trautwine,
Samuel S. White,

ON MODELS.

James Agnew,
J. Sellers Bancroft,
William B. Bement,
Edward Browne,
Charles H. Cramp,
Mordecai W. Haines,
Addison Hutton,
John Kile,
W. B. Le Van,
John L. Perkins.

ON MEETINGS.

Henry Cartwright,
R. C. Cornelius,
Emile Geyelin,
Edward Longstreth,
H. G. Morris,
Henry Morton,
Robert E. Rogers,
Coleman Sellers,
Thomas Shaw,
E. Y. Townsend.

ON MINERALS.

Clarence S. Bement,
John C. Browne,
Isaac H. Conrad,
Emile Geyelin,
R. H. Lamborn,
Albert R. Leeds,
Theo. D. Rand,
Robert E. Rogers,
R. A. Tilghman,
Elias Wildman.

ON EXHIBITIONS.

John Agnew,
J. C. Cresson,
J. Gardiner, Jr.,
Frederick Graff,
Edwin Greble,
Wm. J. Horstmann,
W. A. Mitchell,
T. Morris Perot,
Coleman Sellers,
O. H. Wilson,

ON METEOROLOGY.

Samuel Allen,
Henry Bower,
Pliny E. Chase,
Charles M. Cresson,
Samuel J. Deal,
Jacob Ennis,
Caleb S. Hallowell,
James A. Kirkpatrick,
Benjamin V. Marsh,
Henry Morton.

ON SCIENTIFIC PROCEEDINGS.

Robert Briggs,
E. Geyelin,
Henry Morton,
R. E. Rogers,
Coleman Sellers.

Also, the President appointed as a Special Committee on the subject of Danger Signals—

Henry Morton, Thomas Shaw, John C. Cresson.

Mr. Samuel V. Merrick then announced the death of Professor Bache, which occurred on the 17th inst., and offered the following resolutions, which were unanimously adopted by the members, the vote being taken standing, in token of respect:

Resolved, That by the death of Professor Alexander Dallas Bache, the Franklin Institute has lost its most distinguished member, one to whose labors, while a resident of this city, it was indebted in an eminent degree, for the credit and reputation it obtained for its experiments on Water-power, on Steam Expansion, and on the Strength of Materials.

Resolved, That the Institute will ever cherish in grateful recollection, his services as an Officer and Manager, as Chairman of its Committee on Science, and his generous and warm sympathy with its members in every movement that would add to the progress of Science and the Mechanic Arts, and to the cultivation of liberal opinions and hearty social intercourse and good fellowship.

Resolved, That we sincerely mourn the loss that the family, friends and our whole country has sustained, in the decease of so good and great a man, and we tender our sincere and cordial sympathy and condolence, to all who are specially called on to mourn his loss.

Resolved, That a committee be appointed to attend his funeral, and to pay, on behalf of the Institute, the last tribute of earthly honor and respect to his remains.

Resolved, That Professor F. Rogers be appointed to prepare a necrological notice of Professor Bache, to be entered on the minutes of the Institute, and to be published in its *Journal*.

Resolved, That the President and Secretary be requested to forward a copy of these resolutions to the widow of Professor Bache, with a special letter of condolence and sympathy with her in her great bereavement.

Remarks on the above resolutions were made by Messrs. Fraley, J. C. Cresson, Robert E. Rogers and Robert Briggs, after which, all other business being suspended, as a mark of respect to the memory of Professor Bache, the meeting was, on motion, adjourned.

HENRY MORTON, *Secretary*.

Bibliographical Notice.

For the Journal of the Franklin Institute.

NOTES ON POLYTECHNIC SCHOOLS IN THE U. S.

By S. Edward Warren, C.E., Professor of Descriptive Geometry and Geometrical Drawing, Renss. Poly. Ins., Troy, N. Y. John Wiley, N. Y., Publisher.

Professor Warren, in his little pamphlet before us, has endeavored to give a concise and lucid description of polytechnic schools, with their "nature," "position," "aims" and "wants;" and, although we must take occasional exceptions to some of his remarks, it is in the main a most valuable addition to our educational literature, and we could wish it in the hands of all those who have the correct scientific training of our young men at heart. To properly appreciate the necessity of the popular mind being turned to this branch of education, we must reflect upon the past, present and future of this country. Great and marvelous as has been the growth of the United States during a comparatively brief period, it sinks into insignificance when we consider what the present rate of progression must necessarily bring about in the way of the future development of the arts and sciences.

While a younger people, with all the rich resources of a vast country lavished at our feet, it could not be expected that much attention would be given to an economical utilization of those resources. But now the rapid and almost incredible increase of our public improvements, those great civilizers of mankind, involving millions of dollars, demand that there shall be men specially educated for such works, not only in order that capital may be utilized to its fullest extent, but also that, by a proper care, the natural products of the country may be economized in every way. It has been within but a brief period that the educators of this country have realized these facts, and for many years the Rensselaer Institute (founded 1825 and remodeled in 1850) was the only institution in the land that pretended to prepare young men for the intelligent discharge of the duties of the engineer and technist. It was a start, however, and the Rensselaer Institute may be considered the pioneer of that class of schools whose especial object is the scientific and practical training of young men in the various departments of the arts and sciences.

Professor Warren begins by giving a list of such schools in the United States, with as brief explanatory notes as possible, so that a proper conception of their specialities may be had. The list, in the form of a table, gives the courses pursued at each institution, with the length of each course, the degrees conferred, and also the total attendance during 1865, with the age required for admission. From it we learn that there are eighteen such schools, all of which, with two

exceptions, are located in the Northern States. Of these two exceptions, one is not in operation and the other is imperfectly developed.

In treating of the educational in general, and the preparation necessary for a polytechnic training, Professor Warren, in a necessarily abstract way, endeavors to show that polytechnic schools are, in every sense of the word, professional, equal and, in some respects, superior in dignity to those schools that are popularly recognized as such. We are to view "science" in its "subjective" or "objective" relation to man. The former embodying what relates to his physical or spiritual constitution, the latter relating to all external nature upon which man is dependent for his comfort, happiness and well-being. It is the latter that lies at the root and is the foundation of all technical professions in their various ramifications, as well as the "material fine arts of architecture and music." Surely there is no nobler operation of the mind, than when turned to the study and utilization of the external universe, bending all things to minister to the crowning member of creation—man. There are three decisive tests, Professor Warren goes on to say, which determine the professional character of a school. * * "the *talent* demanded by them, the *extent* and *elevation* of their *courses* of *study*, or the *magnitude* and *beneficence* of their results, stand in two distinct groups, '*Humanistic*' or '*Polytechnic*.'" The former embodying such professions as the law, medicine, theology &c., and the latter, engineering, physics, chemistry, &c.; the one subjective science, the other objective.

We are glad to see, when speaking about the various modes of instruction, the author giving his experience as against the system of lecture instruction. Not that he desires to do away with the system entirely, but to restrict its use to those matters purely descriptive, "in which an error does not vitiate the whole," to "experimental subjects which address themselves largely to the senses," and to "mathematical subjects only in the case of proficient students." To this last exception, we must remind the author of a remark in the same paragraph, where he well and truly says, "that all knowledge of mathematical subjects must necessarily be exact or worthless." Now, we hold that this will apply to advanced or proficient students, as well as to those struggling along the outskirts of that dry and arid science. *All* mathematics require thought and study, of various degrees of intensity, and no step can be taken forward, before the last one made is firmly planted and free from all danger of backsliding. What thought, we ask, can a student, no matter how brilliant or how proficient, give to his professor lecturing upon a new demonstration. No man can think in such a science as rapidly as men ordinarily talk in a lecture, and by the time one has grasped a preliminary idea, his professor is three or four steps in advance, and he is vainly endeavoring to "catch up." With the best of text-books, explanitory matter is needed from the instructor, but the student has the main thought before him, knows all his forms to be correct, and derives that confidence that the certainty

of each step gives, which is requisite for a full comprehension of the matter in hand.

We must ever remember, that in mathematics, one thought or meaning lost, renders the rest worthless. It takes but one rotten egg to spoil a whole barrel of good ones.

The hampering of professors, too often practised through a false economy, or perhaps ignorance, by making them discharge the functions of the tutor, Professor Warren protests against, gently but firmly, a righteous protestation, we think. A relief from these duties gives the head of the department opportunity for original research, so necessary for a healthful growth, relieves the professor from feeling himself a mere machine-instructor, and gives him a zest and zeal which cannot but react similarly upon both the students and school.

The daily labor in a polytechnic school can hardly be judged of by the number of hours required in its service; for, as Professor Warren remarks, when we take into consideration the engineering field exercise, laboratory and drawing-room practice, the "activity is largely physical as well as highly pleasant and invigorating." So that when we reflect upon these things, the diversion of time recommended by our author, "eight hours for sleep, an hour and a half for dinner and an hour for each of the other two meals, including healthful repose, makes eleven and a half hours, leaving twelve and a half for work," (page 18,) reduces itself nearly to, but about, "six hours mental activity," which experience shows is not wearysome in the least, and *ought* not to be burdensome.

Passing over the first part of the third section of the pamphlet under review, which treats of the nomenclature of schools in general, and their adaptation to polytechnic schools in particular, the peculiar functions of the professor are treated of, as well as his relation to the student, and reciprocally the relation between student and professor, and the spirit that should actuate them.

A short paragraph or so is devoted to exposing the foolishness of styling one man professor of engineering,—in other words, professor of a whole science. As well call one man professor of "medicine," a science embracing pathology, anatomy, surgery, &c., &c., each one of which contains enough in its study for one man to devote a whole lifetime to—or call a man professor of the "law," as if a single individual could master that vast subject in all its ramifications, and in all its entirety.

The few remarks of the author upon the spirit of polytechnic schools, are sensible and natural, and he takes a broad and comprehensive view of the relation of students to such schools. Like the student of law, theology or medicine, the polytechnic student is differently situated from the college or university student. Here a young man has chosen his profession for life, success in which depends upon his ambition to excel, followed up by a hearty and zealous attention to all labors and the course of training necessary for an entrance into the practice of his profession. It is this spirit that permits a professional school to

lack the appearance of discipline and control, that must be exercised by the liberal educational colleges, the great majority of whose students have no special object in view in their studies, and no anxiety, except, perhaps, the "cramming" for an examination. Professor Warren thinks that secret societies cannot, from their exclusive nature, flourish in polytechnic institutions, where the course of instruction is such as to inculcate a spirit of united research. Nor is it desirable that they should do so, as the history of all colleges, where they have a deep root, shows; there they are a sad draw-back to the prosecution of study, and cultivate conviviality and sociality, pretty much to the exclusion of all else. In speaking of literary societies as such, the author thinks there is no room for them in the schools of which we are speaking, but he recommends, if the disposition of students is such as to aggregate themselves into organized bodies, their organizations should be strictly scientific in their nature, "provided, that every member of them is qualified to contribute something, and pledged to do it," in the shape of original research, solutions of problems and discussions of special cases, and contributions of industrial drawing. Another object that he mentions may be introduced into such a society, is, through its graduates and others, to make collections of valuable professional reports, and of valuable papers and pamphlets bearing upon educational matters relating to the profession. In this way, and in this way alone, Professor Warren thinks that societies may be useful adjuncts of a polytechnic school—in any other form he evidently views them as pernicious. In an abstract way we heartily agree with him; but taking the bull by the horns, we must own that it is impracticable, simply because the age and immature habits of study in the student prevents him from appreciating such a decidedly voluntary effort, involving much outside study, when he considers the time exacted from him by his professors sufficient employment. Nine men out of ten, no matter how faithful they are in the discharge of their school requirements, prefer to devote any outside time that may remain to them, in recreation. We have now arrived at a subject of great interest, and that is, the proper qualification for entrance to polytechnic schools.

Of course, it is desirable that applicants for matriculation should have a thorough, liberal education beforehand, just as it is considered necessary for young men who intend to study law, medicine or theology. Professor Warren has tabulated the proportion of graduates in a few of the most important technical schools, and it is gratifying to find that there is a yearly increase, although small, in the applicants for professional matriculation, holding college degrees. Taking one instance, at random, in the Rensselaer Polytechnic Institute, we find that in 1860 there were three of seventy-five, while in 1865 the ratio had risen to ten in one hundred and fifty-two. A higher standard should be insisted upon than that now existing, and although it would be impossible to bar all except collegiate graduates, still we would advocate a rigid matriculation examination in all departments of a thorough English education, and that no applicant should be passed

merely because a mathematical proficiency is shown. Many young men, with a natural gift for mathematics, are passed in some institutions, who have an utter disregard of their mother tongue, and although they perform their *professional* exercises well through the whole prescribed course, graduate with no more idea of grammar and spelling than when they entered. And this is no fault of the school; for, as before remarked, such schools cannot pretend to teach other than professional matter, having nothing to do with matters pertaining to a liberal education. This difficulty, Professor Warren feels, and calls attention to: "The great want of polytechnic schools, is a class of preceding institutions." Institutions where the scientific and fruitful French and German living languages and modern history are substituted "for ancient history, and the dead languages of still more dead gods, and their corrupt intrigues," these need not be independent institutions, but part and parcel of our colleges and universities, which still are wrapt in a musty precedent of antiquity. There is some hope for a change in this respect, for there is undoubtedly a ray of light struggling to scatter the accumulated dust of ages, dimly but surely, and we hope that before another decade passes by, that the trustees of our universities and colleges will have fully waked up, and realize that we are not living in years long since gone bye, when there was no other literature but that of Greece and Rome, but in an age teeming with intellectual thought and vigor, the products of which should form the principal part of a liberal education. There is a point not touched upon in the work before us, but of vast importance, and that is the peculiar qualifications which should be embraced in the head of such a school as a polytechnic institution.

A polytechnic school is eminently practical, or should be so, to realize its full meaning. All its theoretic and scientific training should have a practical bearing. The higher classes are, it is true, intended to be so, but how far do they succeed? A young man receives his diploma of civil or topographical engineer, or perhaps bachelor of science or doctor of philosophy, and we ask, how far is he qualified to enter upon the *active* practice of his profession? We admit that the maximum time allowed in this country for our technical schools is insufficient for the practice desirable, but is all the time so appropriated economized to the best result? Let us go back a little further, and see who constitute the faculty of such a school, whose avowed object is to fit men for practical life. They are men learned in the several specialities, so far as books can teach them, students variously gifted, but always students, who have never been themselves one day in the field or workshop, or on public works of any kind. All the book-learning in the world will not take the place of practical experience. To be sure, all professors are not required to have had this experience, nor is the matter which they teach capable of anything but book instruction,—for instance, the chair of descriptive geometry or geometrical drawing,—that of pure mathematics or rational mechanics. But what we do hold, and the point that we are desirous of

making, is, that he who holds the chair of *applied* mechanics, or geodesic or construction, should have graduated in the school of public works, as well as being learned in the theory and science of his profession. He then would know what the student actually needed, and could cater to his wants, economizing to the *best advantage* a time already too short. After a student has mastered the theory of his profession, it is the detail and every-day practice that he wants and must have. Of course, correct models are essential, and models too of what he probably will need in *his own country*, and there is no detail of construction too mean to be useful to him. Those institutions where models are used, have usually examples of the elegant European work, such as for years to come could not be applied in a new country. The problem in all the public works of this country is, to do the most effectual work with the least possible outlay, a view that ought always to be kept before the American polytechnic student, and a view too that marks a line of demarkation from the practice of the continental schools. How many professors, who teach, for instance, bridge-construction, could go upon the ground and superintend the construction of a bridge of the simplest character? They could calculate the strains and proportion, perhaps the parts, but have no more idea of the framing or fitting up than a school-boy. What our schools need, is to have at their *head* one who, besides his education and student preparation, has been connected with various public works, and become familiar with the facilities of the workshop and foundry, and essentially practical in his own experience. Such men can be gotten, if the proper means are employed to secure them, and, above all, a proper compensation offered. Then, and not till then, will our polytechnic schools take that rank as practical and scientific educators that their name implies. How many students would a medical college, or a law school have, if the professors of the various departments had found all their knowledge from books, and had neither attended a patient in the one case, or tried a cause in the other? Here we leave the subject for the present, and advise all who feel interested in the matter in hand to invest in Professor Warren's little pamphlet. In conclusion, we must thank the Professor for his valuable contribution to educational literature, and at the same time remind him of his *quasi* promise of a fuller treatise next time.

B.

A COMPARISON *of some of the Meteorological Phenomena of* JANUARY, 1867, *with those of* JANUARY, 1866, *and of the same month for* SIXTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11¼′ W. from Greenwich. By PROF. J. A. KIRKPATRICK, of the Central High School.

	January, 1867.	January, 1866.	January, for 16 years.
Thermometer—Highest—degree	42·00	52·00	·65·00
" date	5th.	13th.	29th, '64.
Warmest day—mean	37·00	43·67	58·33
" " date	6th.	13th.	15th, '63.
Lowest—degree	9·00	—9·00	—9·00
" date	. 16th.	8th.	8th, '66.
Coldest day—mean	16·00	2·67	—1·00
" " date	30th.	8th.	9th, '56.
Mean daily oscillation	10·61	12·52	11·89
" " range	5·03	7·20	6·48
Means at 7 A. M.	23·29	27·47	27·48
" 2 P. M.	29·29	33·98	34·81
" 9 P. M	26·23	29·53	30·72
" for the month	26·27	30·33	31·00
Barometer—Highest—inches	30·443	30·757	30·757
" date	30th.	8th.	8th, '66.
Greatest mean daily pressure	30·407	30·665	30·665
" " " date	30th.	8th.	8th, '66.
Lowest—inches	29·337	29·565	28·911
" date	21st.	13th.	23d, '53.
Least mean daily pressure	29·426	29·642	29·086
" " " date	10th.	13th.	23d, '53.
Mean daily range	0·225	0·181	0·216
Means at 7 A. M	29·918	29·999	29·957
" 2 P. M	29·883	29·960	29·916
" 9 P. M	29·919	29·991	29·946
" for the month	29·907	29·983	29·940
Force of Vapor—Greatest—inches	0·183	0·309	0·505
" date	21st.	20th.	11th, '58.
Least—inches	·042	·024	·023
" date	30th.	8th	22d, '57.
Means at 7 A. M	·099	·127	·131
" 2 P. M	·109	·131	·146
" 9 P. M	·101	·133	·142
" for the month	·103	·130	·140
Relative Humidity—Greatest—per cent	94·0	100·0	100·0
" date	20th.	15th.	Often.
Least—per cent	40·0	32·0	24·0
" date	5th.	4th.	25th, '60.
Means at 7 A. M.	76·3	78·3	79·5
" 2 P. M.	66·3	62·2	67·5
" 9 P. M.	68·7	77·0	75·9
" for the month	70·4	72·5	74·3
Clouds—Number of clear days*	12·	8·	9·1
" cloudy days	19·	23·	21·9
Means of sky covered at 7 A. M	52·9 per ct	69·7 per ct	62·2 per ct
" " " 2 P. M	60·0	56·8	62·4
" " " 9 P. M	42·9	56·4	48·5
" " for the month	51·9	61·0	57·7
Rain and melted snow—Amount—inches	1·925	2·885	3·156
No. of days on which rain or snow fell	8·	7·	10·5
Prevailing Winds—Times in 1000	N 69° 9′ W ·424	N 61° 3′ W ·310	N 61° 52′ W ·325

* Sky one-third or less covered at the hours of observation.

JOURNAL
OF THE
FRANKLIN INSTITUTE
OF THE STATE OF PENNSYLVANIA,
FOR THE
PROMOTION OF THE MECHANIC ARTS.

VOL. LIII.] APRIL, 1867. [NO. 4.

EDITORIAL.

PNEUMATIC DESPATCH.

THE great length and crowded state of chief thoroughfares in many of our principal cities through which great quantities of merchandise in small packages as well as mail matter, are daily transported, is drawing public notice in no small degree to the plan which is now, and for some years has been, in successful operation between the terminus of the North-western Railway and one of the District Post Offices in London.

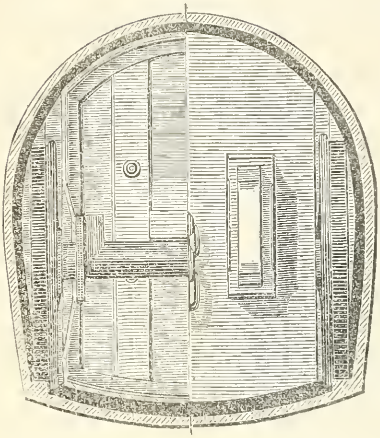
Under these circumstances, we think it desirable to give a detailed account of the above apparatus and its operation, the material for which is derived from an editorial article in the *Practical Mechanics' Journal* for June, 1863.

The general principle of the Pneumatic Despatch may be briefly explained as follows:

A small cast iron tunnel or tube, arched above, but nearly flat below, about two feet nine inches high, and having nearly the same width at its broadest part, provided with a pair of rails, runs from one station to the other. On these rails run four-wheeled wagons, of which Fig. 1 shows an end view and half cross-section. The general

outline of the wagon conforms, as the drawing shows, to the section of the tunnel, but there is an absolute clearance all around, *of more than an inch.*

Fig. 1.



The tubes composing the tunnel are cast in ordinary lengths, and are put together with leaded joints, like the ordinary water or gas mains. They are laid with gradients, varying from 1 in 100 to 1 in 80, and with three curves, two of one hundred and ten feet radius and one of forty feet. This last curve is very short, but works well, and proves the admirable flexibility of the system.

The apparatus for giving motion to these carriages, is situated entirely at one end of the line, namely, at the Euston Station, and may well be considered, on account of its novelty, efficiency and singular operation, as the most remarkable feature of the whole apparatus.

Fig. 2.

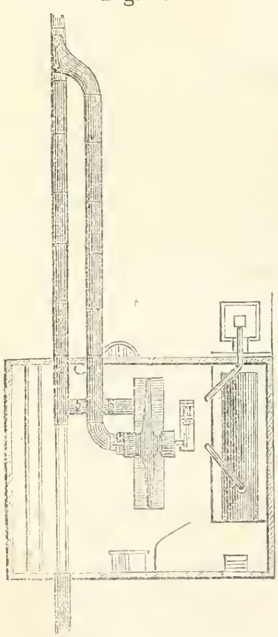


Fig. 2 shows in ground plan the position of this motor in its relation to the boiler, engine and tunnel, and Fig. 3 shows on larger scale, a vertical section of this apparatus, which is known as the Pneumatic Ejector.

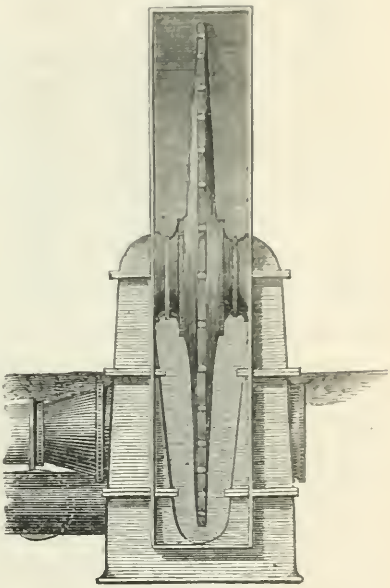
This consists of a hollow circular disc of sheet iron, shown edgewise in the middle of Fig. 3, supported on a short horizontal axis, to which a small high-pressure engine is directly geared. This disc is inclosed in a rectangular, round-topped casing or box, of boiler-plate, twenty-two and a half feet wide by four feet thick. Connected with its lower portion at one side, is a large tube or continuation of the tunnel, while another similar tube, leaving the tunnel at a point more distant from its terminus, (see Fig. 2,) forms a connection

with the interior of the hollow disc, by means of the air-trunk, which is seen in Fig. 3, to surround the lower half of the rectangular casing.

This air-trunk may, however, by appropriate valves, be shut off from the tunnel and opened to the outer air, as also may the rectangular casing mentioned before.

The action of this instrument in a general way, may be easily described. The hollow disc being rotated by the engine, draws in air at its centre from the air-trunk, and expels it into the rectangular case. If the former is connected with the tunnel, and the latter with the outer air, a partial vacuum is produced, and cars are sucked through from the further station. But when the casing is connected with the tunnel, and the air-trunk with the atmosphere, air is forced into the tube, and drives a carriage from the nearer to the further station.

Fig. 3.



Thus much for the general statement; but it will be observed that the form of this pneumatic ejector, or blower, is unusual, and may well demand closer study.

The hollow disc already mentioned, is about twenty-one feet in diameter, formed of two thin sheets of iron, which are but two inches apart at the outer edge, but separating as they approach the axis, so as to form such surfaces of revolution as would be generated by curves, which are nearly hyperbolas, having a common asymtote at the axis, and terminating at the periphery, in tangents, almost parallel to each other and to the plane of revolution.

These discs are stiffened and connected by radial ribs, and the shaft is fixed in them by rib-feathers. Circular mouths at the centre of the discs, correspond to similar mouths terminating the air-trunks, with which they make tight joint by means of ordinary cup-leathers.

The property of the curve which determines the shape of the disc, is, that a circumferential section at every distance from the axis, shall

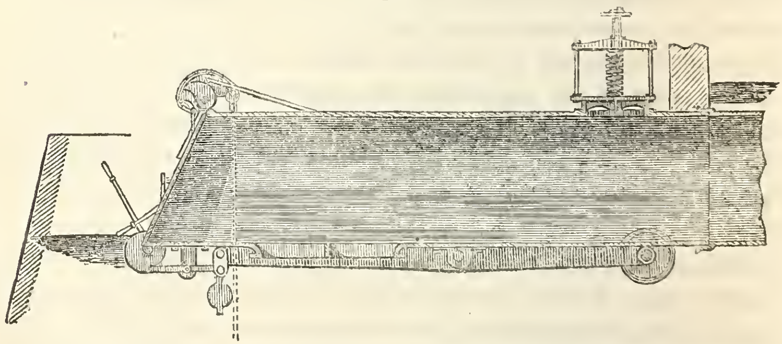
have the same area, which also equals that of the indraught openings just described.

This remarkable "ejector" appears capable of giving a higher duty than any fan previously used, and the actual pressures obtained, as will be seen from the following table, are strictly proportionate to the square roots of the velocities:

Diameter of Ejector in feet.	Number of revolutions per minute, and pressure in inches of water.							
	50	60	70	80	90	100	110	120
20 feet.	0·65	0 94	1·27	1·66	2·11	2·63	3 15	3·74
21 "	0·73	1·04	1·42	1·85	2·35	2 90	3·51	4·18
22 "	0·83	1·19	1·62	2·11	2·67	3·29	4·00	4·75
23 "	0·87	1·26	1·71	2 24	2·83	3·48	4 33	5·04
24 "	0·95	1·36	1·86	2·43	3·07	3·73	4 59	5·49
25 "	1·02	1·47	2 00	2·62	3 32	4·11	4·96	5·90
26 "	1·12	1·62	2·20	2·88	3·64	4·45	5·44	6·48
27 "	1·20	1 72	2·35	3 07	3·88	4·79	5·80	6·91
28 "	1·30	1·87	2·56	3·32	4·21	5·15	6·29	7·48
29 "	1·37	1·98	2·68	3·52	4·45	5·53	6·65	7·92
39 "	1·47	2·12	2·89	3 77	4·77	5·92	7·13	8·49

By the use of this ejector, (which is, in the case under consideration, run at the rate of one hundred to one hundred and ten turns per minute,) and of appropriate valves in the connecting pipes, the cars are *blown* through the tunnel from the Euston Station, or sucked back from the further terminus. In the first case, the necessary supply of

Fig. 4.



air is obtained from out of doors, by means of passages under the floor, and in the latter the outdraught is discharged by the same means.

The arrangement for allowing the car to come out of the tunnel at either terminus is shown in Fig. 4, which represents the termination of the tube with its various appliances. Above, at the right, is seen a spring-valve, which may be so adjusted that the resistance offered to the escape of air from in front of the car, when near the terminus, may be such as to bring it to rest at a convenient point outside. Vertically under this, is seen a wheel at the end of a long lever, upon which presses the advancing car. This lever thus depressed, sets free at its other end, the detent of the door, which closes the tube or tunnel, and a counterweight then quickly raises this last, a moment before the car reaches it.

The velocity at which the cars or trains are run in this tunnel, is about sixteen and a half miles an hour, the short curves before mentioned necessitating a reduction of speed. This velocity is obtained by the use of a twenty-two foot ejector, making, as we have said, one hundred to one hundred and ten turns per minute, which develops a pressure of three to four inches on a water-gauge.

Motion is given to the ejector by means of a small steam-engine of fifteen inches diameter and sixteen-inch stroke, set upon an inclined framing, and having its crank keyed directly to the shaft of the ejector. The steam is used at a pressure of forty pounds.

About fifteen trains, each way, are now the daily work done by this apparatus, which is clearly but a small per centage of its capacity; and to effect this, steam must be kept up all day, by which great loss of duty occurs; yet the whole consumption is but twenty-one bushels of coal per diem, at a cost of 6*s*., or about 5*d*. per double journey.

The general arrangement of parts and ground plan of the Euston terminus, is shown in Fig. 2, where we see at the right the boiler next to it, the engine attached directly to the ejector, from which two tubes lead to the tunnel, a long one for suction, and a short, direct passage, for blowing. Opposite to the end of the tunnel, on the further side of the room, is a short closed passage, which acts as an air buffer to the cars, should the valve arrangement before described fail to bring them to rest at the desired point, namely, on the track between these two.

From the foregoing statement, it will be seen that the Pneumatic Despatch, as devised and arranged by Mr. Rammel, and as practically operated in London, possesses many marked features by which it is distinguished from all the pneumatic railways and the like, which have been before employed.

The loose fitting of the car in the tube, the low-pressure and large quantity of air employed to drive the trains, as well as the peculiar form of the ejector, are all novelties of great importance to the success of the scheme. It will also be noticed that the speed is not high, and it should be remembered in the discussion of similar plans, that to employ a high speed for long distances, would demand an accuracy and permanency in the tunnel or tube hardly to be reached under the existing conditions of the problem, in an engineering point of view.

Engineering Items.

An immense reservoir.—M. Morin presents, in the name of M. Graeff, Chief Engineer of the Bridges and Embankments in the Department of the Loire, an account of the reservoir of Furens, near St. Etienne, in these words:

Since the presentation which was made by M. Graeff on the 23d of April, 1866, which was an account of the theory of the motion of water in reservoirs, which served for irrigation, one of the reservoirs in which this theory has achieved entire success, has been erected at Furens.

The city of Saint Etienne, in which formerly a subterranean basin was used, to hold, at the source of the Furens, all the necessary water, has contributed a sum of at least one million, for the construction of this reservoir by state engineers. By this work, the city secures the right of using this reservoir for storing the superabundant water of the Furens during the spring and autumn, and in fact to use it for municipal purposes, and for regulating the supplies during the droughts of summer and winter, to the manufactories, of which there are sixty-eight on the stream.

The old bed of the Furens, in the part where it forms a vast basin, has been shut off down the river by a bar fifty metres, or one hundred and sixty feet, high, of which the profile was adjusted according to the type of equal resistance. This bar is made entirely of ordinary masonry, and only the cap is composed of regular blocks, which are of cut stone; the bar is founded on a rock which encases its base and sides.

It was commenced in 1862 and finished in 1866, and was officially inaugurated on the 28th of October, though it was filled in the spring, and furnished, during the summer, the city and manufactories of the valley.

At its greatest rise, the Furens did not give out more than 15 cubic metres in a second, from observations made during ten years by M. Graeff, but on the 10th of July, 1849, a water-spout occurred in the valley, which was at least 6175 acres in extent, and there resulted from it an inundation of the city of Saint Etienne. This immense overflow reached the great volume of 4624 cubic feet in a second, and subsequent observation showed that the invasion of the city by water, did not occur until the out-flow of the Furens attained 3284 cubic feet a second, which was very unusual.

The observations made of the quantity of water given out in this condition, led to the conclusion that the reservoir, to which these extraordinary rises furnished 3284 cubic feet in a second, should be capable of receiving 7,063,000 cubic feet. It was constructed large enough to accommodate 14,126,000 cubic feet, or twice the amount which was produced by the water-spout of 1849.

According to arrangements made in this immense reservoir which has just been erected, it becomes easy to hold in reserve twice a year, spring and autumn, 84,750,000 cubic feet, which can gradually be dispensed to the city and manufactories. The first cannot possibly use more than 21,189,000 cubic feet, and there then remains 6,357,000 cubic feet to divide between sixty-eight manufactories.

These details suffice to show the importance of similar works, for changing courses of torrents, which so often cause devastation and disaster, into reservoirs which are necessary to the health of cities as well as to arts and manufactures.

The whole cost of the reservoir was about $800,000, and the revenue received pays fully five per cent. on this, without counting the increased value of the manufactories supplied from this source.

The Paris belt railway was opened on the 25th of February; it is 22 miles in length, including the branch to Mt. Parnasse, and is entirely within the city walls, crossing the Seine at two points, about seven miles apart, by bridges, one of which at the Point de Jour, is very remarkable for the beauty and ingenuity of its structure.

A railway and road-bridge over the Po, at Mezzana Corti, has just been finished. Its length is 3310 feet, made up of ten spans of 196 feet, with the piers and abutments. The superstructure con-

sists of two lattice girders 24 feet 6 inches deep, placed 27 feet 3 inches apart, and connected below and above by plate iron cross-girders. The cross-girders below, are connected by short plate-girders under the timbers on which the rails are placed. The lower system of cross-girders carries a double line of rails, and the upper a roadway. The upper cross-girders have an arched form on their upper surface, and are connected by longitudinal timbers on which the planking for the roadway is laid. The most remarkable feature of this bridge is, however, the substructure and the method of its formation. Iron caisons 49·2 feet by 19·2 feet, and 8·8 feet deep, closed at top but entered by four tubes each four feet in diameter, provided with skips and equilibrium chambers, were sunk upon the site of the piers. Compressed air was used to remove and exclude the water, and workmen and materials were introduced by means of the tubes, &c. The whole interior was finally filled in with concrete.

The Hoosac Tunnel is again let to contract. When finished, its extent will be 4½ miles, of which as yet only 4600 feet are finished. The central shaft is to be elliptical in section, 27 by 15 feet, and will have a depth of 1030 feet; only 400 feet have as yet been sunk.

The London and North-western Railway, as we learn from our excellent cotemporary *Engineering*, has a capital of $350,000,000 and forty miles of double track laid with steel rail.

Steel-faced armor-plates capable of resisting chilled shot, which have been found to penetrate the ordinary armor, have been manufactured by Messrs. Cammel & Co., of Sheffield, in slabs having a surface of 48 square feet, and a thickness of 6 and 7 inches. Each plate weighs about 6 tons. The weld is said to be readily effected in the rolling, and to be very good.

Railway across the English channel.—The President of the London Society of Engineers, in his inaugural address for this year, alludes to the project above-named, in the following manner, as we learn from the *Mechanics' Magazine:*

"At the present moment it is proposed to bring together nations between which there is a sea of twenty miles, and there would appear to be no substantial reason to consider this task impossible either by the construction of a multiple span bridge or a subway across." Which shows us that this stupendous enterprise is contemplated in a serious and even practical light by others than its proposers.

The English iron trade.—From the same authority, the address

of Wm. H. Le Feuvre, Esq., we quote the following remarkable statement, which must interest our readers, since the facts related cannot fail to have a world-wide influence upon one of the most important industries.

"I would desire to call your attention also to a circumstance which has lately begun to assume a serious importance to us as engineers, and which promises to endanger one of the most extensive of our manufactures, that is, the production and manufacture of iron. This has been carried on to such an extent now in Belgium, that, after an interval of a very few years, the run of competition is altogether on the side of Belgium manufacture. They successfully compete with the most extensive of our iron works in England. As examples, I would mention, that during the progress of the Exhibition lately erected in Amsterdam, it was found that while the earlier portions were being constructed, it was cheaper to import the iron-work from England; but before the work was completed a considerable quantity of iron-work was supplied from Belgium and Holland, as it could be obtained at a lower price, and from that period to the present, the competition has run hard between those countries and our own. In the new Pimlico Wheel Works, in London, which, as may be known, perhaps, to most of you, was constructed by our firm, we had also to give way to the importation of iron-work from Belgium, and it is the case also with regard to some works we are now carrying out in India, where the iron-work is actually shipped from Belgium to London and reshipped to Bombay, at a less cost than it could be purchased from English manufacturers. I cannot but view these circumstances with regret and apprehension, and I hope that before such a state of things is permitted to become more serious, some co-operation may be induced amongst our leading manufacturers, so that this branch of our industry may be not altogether wrested from us. I mention these instances as facts which have come under my personal observation and experience. We find one of our leading railway companies (the Great Eastern Railway) being provided with locomotives from France, which resulted after a competitive tender, to which our leading firms were invited. The inroads of foreign competition have at length reached to such an extent that one of our leading railway companies invited a French firm to compete with our manufacturers for the supply and erection of the iron-work of their terminal station in London. I cannot, therefore, but repeat that there are good grounds for the fears entertained with respect to this branch of our industry, and trust that

these remarks may lead to some practical suggestions being made during the present session, with the view of ameliorating the present condition of our iron manufacturers."

In reference to the above statement, we should mention that the editor of *Engineering* explains this effect as resulting only from that revolution in iron manufactures which the general introduction of the Bessemer process has inaugurated, and which has rendered the great coal regions no longer the best location for iron-making, but rather the localities where the best iron is found. The reason of this is, that while formerly an inferior ore could (by great expense of coal in refining) be converted into a first rate iron, we now can at once (provided we start with a good ore) obtain a superior iron or steel with a very small outlay of coal. The old refined iron thus finds itself unable to compete with the new steel. As England takes the lead in both of these branches, however, the new as well as the old, nothing is to be feared in the future from the development and change above noted.

Boiler explosions and their prevention.—Since we last alluded to this subject in our previous issue, the account of two boiler explosions, which might have been prevented by a thorough system of inspection, and which resulted in the loss of fifteen lives, has reached us in the Reports of the Manchester Association, published in the *Mechanics' Magazine.*

The first of these, was the explosion of a small portable boiler on a sailing vessel, where it was used to drive a windlass engine for hoisting cargo. A precisely similar boiler, from the same manufacturers, exploded a few months before, with like disastrous effects. This boiler was a very small one, 5 feet high 2·5 feet in diameter, with internal conical fire-box and two horizontal water tubes; working pressure, 100 lbs. The cause of explosion was very evident, the man-hole, 13 by 10 inches, was not strengthened by any mouth-piece, or ring, but had only an ordinary internal cover, supported by one or two bolts suspended from arched bridges. The shell was ripped in every direction, radially from this hole. By the explosion of this small boiler, five men were laid dead upon the deck, two were blown overboard, and one fatally injured, while the vessel itself, with bulwarks splintered in every direction, and deck drenched with blood and strewn with dead bodies and fragments of iron, presented a spectacle horrible beyond description.

The safety-valve with which this boiler was provided, proved also to be of a most improper and *unsafe* construction, being so arranged that

its adjustment (with a spring, a set screw) was a mere matter of guess-work, so that it was at any time a matter of doubt whether it was arranged to lift at 50, 100 or 200 lbs. pressure.

The second explosion which occurred, was in a dye-works, and resulted in the loss of seven lives and the demolition of the whole building. It was the result of using bad iron in a cylindrical flue boiler, internally fired, carrying 100 lbs. pressure, and quite new. The owners of this one had bargained for a boiler to be of the best material and abundantly strong, and had paid an unusually large price to the builders, on their assurance that such was the character of the article supplied. On the inquest, however, the foreman of the manufacturers stated that some of the iron used in the boiler in question, was of very poor quality, and therefore totally unfit for the use to which it was put. It thus appears that a good system of official inspection, would have prevented the use of either of these boilers, and therefore, as a consequence, their disastrous effects.

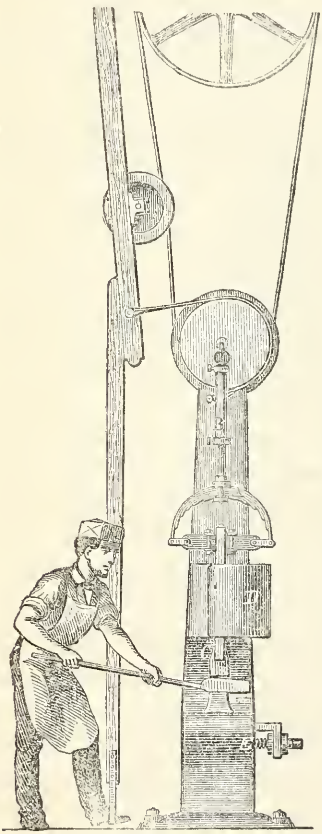
Hoists for iron furnaces.—At the last meeting of the Franklin Institute, attention having been directed by the Secretary in his report, to the hydraulic hoists lately erected at the Rosedale Iron Words, Mr. Coleman Sellers described a similar instrument, which had been for many years in use at the establishment of Messrs. Whitney & Sons, where it was used for moving the car-wheels into and out of the annealing ovens or pits. The peculiarity of this machine is that a system of pulleys are separated by the action of a hydraulic ram, thus securing, by an inverse action of the pulley, a rapid motion in the hoist from a slow one in the ram. The President, Mr. J. V. Merrick, then stated that in many of our iron works, an air-hoist was used with good results. This plan was first introduced by Mr. John Fritz, at the Bethlehem Iron Works, at which two of these machines were now in use, one with a single column, the other with two. The arrangement is as follows: A long cylinder is provided, having the same height as the hoist. This is closed, and has a stuffing-box at the top, through which passes a wire rope, which is attached to a piston within, and passing over a pulley, is fastened at its other end to the platform of the hoist. Air from the furnace blast is supplied to the cylinder at about five pounds, and raises the car with its load, the weight of the piston counterbalancing that of the platform.

Similar hoists to the above are used at the Lehigh Crane Iron Words, Catasauqua, and at the Thomas Iron Works, Hokendoqua,

Pennsylvania. The President further described the plan now largely used in pavement hoists, or those employed to raise goods from stories below the ground to the level of the pavement. In this case the platform was simply supported on the head of a ram, which was raised by the hydrostatic pressure due to the head of water obtained from the mains or from an elevated cistern. Prof. R. E. Rogers also stated that he had inspected a hoist of this description in the Charing Cross Hotel, London, with a lift of 50 feet.

We hear that one of these hydraulic hoists is to be erected in this city, with a lift of 80 feet.

The dead stroke power hammer.—At the last meeting of the Franklin Institute, there was exhibited a model of this improved instrument, in its most efficient form. This apparatus, invented by Mr. Thomas Shaw, and first put in operation by Mr. Philip S. Justice, may be described as follows:



It consists of a ram, which is suspended by means of a flexible connection, such as a leather belt or combination of leather belts, from a cast-steel spring, through which a reciprocating motion is communicated to it, from a crank. The line of motion of the ram or hammer is determined by guides.

It follows, from this form of construction, that the hammer or ram acquires a velocity, not only such as is due to the descending motion of the crank, but also to the accumulated motion or force of the upward stroke, which is absorbed and stored in the spring, and which this spring, from its bow-like shape and action, is enabled to communicate to the ram, in the most efficient manner, that is to say, in such a way as to develop the highest possible velocity.

This velocity, at the moment of striking, will be far beyond that of any other portion of the machine. The effect of a blow increases,

as is known, with the square of its velocity, and we can therefore understand, that even a light hammer, striking the work with the immense speed obtained as above, will produce effects of a character enormously greater than we would expect, when considering only its weight and the motion of the machine generally. Thus, a 25-lb. hammer will forge down 2½-inch bars, with great rapidity; a 100-lb. hammer will forge down bars of 4½ inches; a 1000-lb. hammer will forge blooms of 9 inches; while the little 15-lb. hammer, intended for light work, will readily work bars of 1¼ inches.

Another advantage obtained by this high velocity and light weight, is, that the blow is so sudden that there is no time to communicate the force to the anvil, but the work of compression in the body treated, absorbs a large part of the shock. With a hammer of greater weight and slower motion, this advantage would be sacrificed proportionally, more of the force of the blow would be transferred to the anvil, and less work would be effected in the intermediate piece under treatment. This circumstance secures to the instrument two important features, durability and economy of maintenance. We thus find that one of these hammers, run for a year on very severe work, required *no repair*, while a trip hammer used under identical conditions, averaged $3 a day, the year through, for repairs.

Improvements in oil presses, by John Shinn, were described at the last meeting of the Institute. These consist in the introduction of corrugated surfaces, covered in turn by sheets of iron gauze, between the bags in which the stearine and oil are separated by the action of pressure. By this means the drainage is not restricted to the edges of the bags, but is distributed over the entire surface, by which the process is rendered very rapid and complete.

Novelties in Chemistry and Physics.

Preparation of Oxygen.—Winkler states that bisulphate of soda may be substituted for sulphuric acid in obtaining oxygen from the black oxide of manganese, with the advantage that it forms a fusible mass not so likely to cause breakage of the retort, as the hard cake of sulphate of manganese otherwise produced.

A new chemical toy.—Take a sheet of thick white bibulous paper, without size, such as is used for printed books. Soak it first in

a strong solution of bichromate of ammonia, and when dry, treat it likewise with an alcoholic solution of gum benzoin. Such a sheet, so folded that it will stand on one edge, if lit at its upper edge, so that it burns without flame, is converted as it burns, into a system of green serrated leaves, much resembling those of the fern. It meanwhile emits a pleasant odor.

Experiments illustrating the vibrations of strings.—In the proceedings of the Royal Institution, which we have just received, we find an interesting account of some experiments in the above subject, exhibited by Professor Tyndall, at one of the meetings of the learned society named.

Among these, the following attracted our special attention: A rod was firmly fixed in a vice, in such a way that its shadow could be thrown upon a screen, and was then struck sharply at certain points, by which means it was made to divide itself into two or more vibrating segments and half segments, the former showing themselves as shadowy spindles, and the latter as fans upon the screen. The nodes were marked by dark points of stationary shadow.

Again, a fine platinum wire was connected with a tuning-fork, and heated by a galvanic current. The fork being now caused to sound, the wire received a vibration to which it responded, swinging as a whole, by which means its middle portion was cooled through its rapid motion in the air. The wire being then slacked, divides itself into two or more segments, of which the nodes are intensely heated and the ventres cooled, so that the appearance produced is that of many luminous spindles intensely bright at their points, but fading gradually into darkness at their thicker portions. The nodes show excess of brightness over the wire at rest, because the cooling of the other parts allows more of the current to pass.

Test for amount of Carbon in steel.—It is stated that, in conducting the Bessemer process at Manchester, a quick and sufficiently accurate estimate of the amount of carbon present in any sample, may be made by dissolving a given weight in nitric acid, and comparing the color of the solution with that of a known standard. The brown tint increases in intensity with the amount of carbon present.

Proposed improvement in manufacture of steel.—The renowned chemist, Graham, announces, as the result of some experiments lately made, that iron at a low red heat, will take up by an absorptive action—without chemical union—4·15 vols. of carbonic

oxide. To effect, however, a combination of the carbon here present with the iron, requires a much higher temperature, while this higher temperature, on the other hand, is unfavorable to the before-mentioned absorption. He therefore suggests that an alternation of these temperatures might be of advantage in the process of steel-making by cementation.

The crystallization of glycerine on a large scale, was lately effected by the combined action of the cold weather and the jarring of the cars in which the substance was carried. The crystalline mass, when melted, would not again freeze at a temperature of 0° F. while at rest. While melting, it maintained a constant temperature of 45°.

Useful products of the pine tree are now manufactured at Paris, as follows: Vegetable wadding, raw vegetable wool, flannel, pine extract, spirits and soap.

Ice machine, by M. Toselli.—Some years ago this gentleman devised a simple instrument in which ice was made by the solution of equal quantities of carbonate of soda and nitrate of ammonia in water. In this way a pound of ice was made at the cost of twenty-five cents. He now finds that by dissolving the carbonate of soda first, and then adding the other salt, a much more intense cold is obtained; or, by substitution of a cheaper salt, not named, the same effect can be procured at a less cost. Thus, by his present plan, six pounds of ice cost but ten cents.

Vegetable fibre is converted into a substance resembling inulin, as is shown by Wm. Skey in the *Chemical News*, 1867, page 1, by the action of ammonio-nitrate of copper in solution.

Sodium amalgam, when used for the extraction of *silver*, works with remarkable efficiency, as we learn from various statements and letters published in the same journal.

Wild's magneto-electric machine (of which a full description, with plates, was published in this *Journal* for December), according to a statement published by the Abbé Moigno, in *Les Mondes* and the *Chemical News,* heats very much when run continuously.

Fifteen electric lights were employed to illuminate the *Bois de Boulogne* during a skating féte this winter, as we learn from the same authority. The lights, each produced by forty Bunsen cells, were arranged on elevated platforms or towers erected for the purpose, and illuminated the ponds, the approaches and the skaters, in the most beautiful and satisfactory manner.

A work on spectrum analysis as applied to the heavenly bodies,

illustrated with eighteen photographs of the most remarkable spectra, and of apparatus used in their study, has been prepared by Mr. Wm. Huggins, and published by W. Ladd, the well-known maker of philosophical apparatus.

An electric light is used in the shops of the North Spanish Railway.

Spectroscopes.—From a priced catalogue of these instruments, just issued by John Browning, we extract the following points, which will be of interest to some of our readers. The amateur's spectroscope, stated to be a good instrument, is furnished for £2 2*s*. The direct vision spectroscope (in which the dispersion, without deflection of the ray, is obtained by means of four internal reflections and four refractions in two prisms) may be carried like a small spy-glass, in the pocket, and costs £4 4*s*. The student's spectroscope, so arranged that two spectra may be seen at once and compared, fully adapted to all purposes of analysis, costs £5 5*s*. The model spectroscope, from £10 10*s*. to £50. The star spectroscope, from £7 7*s*. to £18 18*s*. Lastly, the micro-spectroscope, fitted for those tests and examinations described by Dr. Sorby in the last volume of the *Chemical News*, costs £5 5*s*.

The Bessemer process.—We have received from Mr. Z. S. Durfee, 418 Walnut Street, a very interesting pamphlet, describing the Bessemer or Pneumatic process of making iron and steel, with details of the machinery used, the peculiarities of the metal produced, the uses to which it has been applied, and a list of all the works in which this process is in operation.

Photo-sculpture.—We learn from the *Philadelphia Photographer* that the process named above, and whose details (as practised in London) were some time since described in this *Journal*, is now carried on by Messrs. Huston & Kurtz, 895 and 897 Broadway, New York. The theory of the operation may be thus briefly described: Twenty-four photographs are made of the subject, from as many directions, and from each photograph is cut out a profile, which being used as a tool or template upon a block of clay in the corresponding position, produces at last a figure having correct profiles in all directions, and therefore needing but a few touches (developing the re-entrant angles) to render it a perfect likeness. In the plan as practised in England, the sitter was placed in the middle of a platform and turned round by twenty-four movements in front of a single camera.

In the present case, however, twenty-four cameras are employed, and as many plates are exposed at once, thus saving much time and avoiding risk of error from changes in position of the sitter.

Civil and Mechanical Engineering.

(Continued from page 161.)

THE NEW YORK "CENTRAL PARK."

By WILLIAM H. GRANT, Superintending Engineer.

CHAPTER II.

1st.—TRIAL-SAMPLES OF ROAD CONSTRUCTED AT THE COMMENCEMENT OF THE PARK, AND REFERENCE TO THE VARIOUS PLANS.

2d.—PRELIMINARY AND FOUNDATION WORK IN GENERAL CONSTRUCTION.

GRAVEL *roads, Telford roads and MacAdam roads. Theory as to road foundations. Relative cost of the samples. A modification of Telford plan. Preference developed, in the use of the roads, for the gravel road. Total lengths of the roads of the Park, and lengths of the different kinds and widths constructed.* GENERAL CONSTRUCTION.—*Surveys and location of roads. Grades and Curves. Preparation of road-bed. Drainage. Road hydrants. Theory of drainage, rainfall, &c. Observations on the drainage of the Park at large. Recapitulation of the drainage works and water pipes of the Park.*

At the commencement of the road-making operations of the Park, in 1858, three different samples of road were made. Suitable ground was selected for the purpose, on the line of an intended road, the width of which was fixed at 45 feet.

The samples were from 350 to 500 feet in length, and were intended to test, as far as practicable, the cost, relative qualities, merits and facilities of construction of *gravel roads*, *Telford roads* and *MacAdam roads*.

The gravel road was first commenced. The samples were not all entirely completed until the forepart of 1859.

The depth of road material for all the samples was fixed at fifteen inches.

The details of gutters, silt basins, surface and sub-drainage, &c., were matured during the progress of the work.

The only material change that was afterwards made in the plans of the samples was in the reduction of the depth of the road materials.

In the sample of gravel road the stone bottoming was composed of two layers; the first was a layer of stones, from 3 to 5 inches thick,

and 8 to 18 inches long, laid flatwise upon the road-bed, the interstices being filled with stone chips, or spalls. Above this layer was placed the paving, or "Telford" course, composed of stones from 7 to 9 inches in depth, set on edge crosswise of the road, and wedged tightly together, and otherwise treated as will hereafter be described. [See Plate I.]

The object of the double course was, principally, to give the depth of material considered necessary, without the rigidity, and some other inconveniences of construction, caused by using larger and deeper stones in a single course of paving. It was also further considered, that the bottom layer of stones would serve to make a more equable foundation, on soft ground, for the superincumbent materials, and at the same time more effectually prevent the working up of the underlying earth;—as stated at the time in a report made upon the subject, 'The pressure upon any given point, by carriage wheels or horses' feet, will be distributed (by means of the bottom stones) over a larger area, the upper course, wedged and bound together, acting in some measure as an arch, and transmitting and distributing the pressure to the course below. The tendency of the foundation stones to work upward—a matter that has been a good deal discussed by roadmakers—is to be remedied by this means, together with sub-drainage and such an entire depth of road material as to prevent undue action of the frost.'

'The softening of the road-bed, by water retained upon it, permits the stones to settle unequally and become displaced, one end sinking and the other rising, the frost heaving and loosening the mass, and aiding the operation, until the road material becomes generally deranged and imperfect. The method of sub-drainage described, and the depth and form of road materials used, are deemed sufficient to obviate this difficulty in all ordinary cases.' * * * 'The foundation stones, in any upward movement they may be supposed to be subject to, will be met by the resistance of the upper (paved) course which must rise with them in a considerable mass, unless that course is broken up or displaced by some more than ordinary usage or service.'

This was said more especially with reference to the gravel road. The kind of gravel road proposed, not having been before to much extent—so far as I could learn—adopted or proved, as in the case of the Telford road, it was thought the more necessary—as it was uncertain whether the gravel would prove so firm and compact a body of

material over the foundation, and in aid of the foundation, as MacAdam stone—to give the foundation additional security.*

The bottom layer of stones had another advantage, which was that it admitted of using a considerable portion of inferior stones, as it was not necessary that the stones in this layer should be of so good a quality as those in the paving course.

Upon the completion of the paving course, the gravel was deposited on the top, and the road was rolled and finished in the manner that will be more fully described hereafter.

The bottom layer of stones was omitted in the Telford sample, following, in this case, the general plan upon which such roads had heretofore been constructed—that of a single paved course, surmounted with the ordinary MacAdam stone.

The broken stone on the top of the Telford pavement, and also the last five inches on top of the MacAdam road, were from the hard boulder stones of the Park; the first ten inches of the bottom of the latter road being from the less durable gniess rock obtained in excavating for the roadways and other works of the Park.

After the samples were completed, and some facts developed as to their cost, and other particulars, it was decided, on the ground of economy, to reduce the depth of the road material in the continuance of the work, and this left no longer in force the principal reason for adding, in the case of the gravel roads, the layer of stones below the paving course, viz: that of giving the additional depth, &c. It would not have been desirable to compose the bottoming of two courses of stone for the modified depth of materials adopted, inasmuch as both courses would have been lighter, and composed of smaller stones, than would be expedient. The question of cost was an important one, and it was thought best to yield to it, (though there was no doubt of the utility of the depth of material first used,) so far as to restrict the roads next constructed to a depth of about twelve inches.

These three samples have formed a part of the "east drive" of the Park for seven years past, and have remained firm, and preserved a remarkably even surface, under all changes of temperature and wea-

* The only instances of similar gravel roads that had come under my observation previous to this time, were two specimens that I had built on private grounds; the one in the District of Columbia, and the other in Westchester county in this State. The first road had been in use about three years, and I had received very favorable accounts of it; the other was built for my own use, and had not been so long under service.

ther, and under constant service. The sample of gravel road, in particular, has given most satisfactory results.

In recommending the gravel road previous to the completion of the samples, I had stated—

'1st. That a gravel road is best adapted to Park purposes, being the easiest and most agreeable kind of road for both carriages and horses.

'2d. That it is the cheapest as to first cost, and can be kept in repair at an equal, if not less cost, than any other equally satisfactory road.'

These views were expressed after a careful investigation of the subject, and some previous experience, and although not immediately adopted, they have been fully sustained by the ultimate results, as will be seen in the further description of the roads of the Park.

The relative cost of the samples—the details of drainage, silt basins, gutters, &c., being common to all—was about as follows:

Gravel road	1·
Telford road	1·50
MacAdam road	1·75

Omitting from the estimate the bottom layer of stone in the gravel road, and allowing for the reduction of the depth of the Telford and MacAdam roads in about the same proportion, (as was afterwards the case,) gave the following results:

Gravel road	1·
Telford road	1 65
MacAdam road	1·70

The MacAdam stone used in the Telford and MacAdam samples were broken by hand, but a proposal having been made during the progress of the work (which was afterwards accepted) to break the stones by a machine, at a reduced cost, the above estimates of relative cost have been made by using the data of machine-broken stone.

In proceeding with the construction of the Park roads in 1859, the MacAdam and Telford methods were mainly followed during that year. The depth of road material was reduced, as before stated, to about twelve inches. About 7000 feet of MacAdam road and 6000 feet of Telford road were built during the year. The MacAdam road had, as a first layer, a depth of broken gniess stone of 7 inches, with a top layer of 5 inches of the harder boulder stone. The Telford road, in nearly equal portions, was composed (above the pavement), in the one case,

of the hard boulder stone, and in the other of 2 to 3 inches of the gniess stone, surmounted with 3 to 4 inches of the boulder stone.

About 3000 feet of road that was commenced on the Telford plan was modified (owing to circumstances not within the control of the engineer) after the paved foundation was laid, and 2 to 3 inches of broken gniess stone deposited on it, *by substituting in the place of the superior hard broken stone, as had been intended, a light layer of gravel.* The combination of broken stone and gravel was not found to work well. The gravel was surfaced and partially intermixed with limestone chips and stone dust—(refuse from limekiln quarries and detritus resulting from the breaking of large quantities of MacAdam stone,)—and was very thoroughly rolled, but from the want of homogeniety in the broken stone and gravel, a proper bond or union of the two did not take place, and a tendency of the gravel layer to separate and peal off from the stone below was exhibited soon after the road was brought into use. This was especially the case in wet weather, the surface gravel being removed in the form of large flakes by the action of wheels and horses' feet. This portion of road was the least satisfactory (until subsequently remedied) of any of the kinds built, and the practice was not continued.

During the following year, 1860, being the second year that the samples of road had been in partial use, about 2000 feet of Telford road was constructed, and the further extension of both the Telford and the MacAdam roads was thereafter discontinued.

The public use of the sample of gravel road had demonstrated, in the meantime, the qualities claimed for it, and developed a clear preference, on the part of the citizens of New York, for that kind of road. It was evident that they would be satisfied with no other of the tried forms, however perfect and complete they might be made.

During this year, about one mile of gravel road was commenced and mainly completed. The plan was the same as that of the first sample, with the exception that the bottom layer of stone, before mentioned, was omitted, and the depth of road material reduced to about twelve inches. Upon this plan, about half a mile in addition was subsequently constructed, *i. e.*, with the Telford pavement as a base, when the plan was further modified, for purposes of economy, by substituting for the pavement a mere deposit of rubble stones, and with this latter modification, gravel roads were thereafter exclusively adopted for the remainder of the work. [See Plate II.]

The following statement shows the total length of the Park (car-

riage) roads, the lengths of the different kinds of road, and the different widths:

KINDS OF ROAD.

		Miles.	Feet.
MacAdam Road.	—Material all of broken stone	1	2,434
Telford Road.	— Sub-pavement, with broken stone on top	1	1,684
————————	Sub-pavement, with a layer of broken stone intermixed with a top layer of gravel		3,038
Gravel Road.	— Sub-pavement, with gravel on top	1	1,070
Do.	Quarry rubble-stone bottom (not paved) with gravel on top	4*	5,145
	Total	9	2,811

LENGTH OF ROADS OF DIFFERENT WIDTHS.

Widths.	Miles.	Feet.
55 to 60 feet	1	1,795
50 to 55 "	0	2,491
40 to 45 "	3	2,206
30 to 33 "	4	158
16 to 25 "	0	1,441
Total	9	2,811

With this general reference to the subject, I proceed to a more full and detailed description of plans and materials of construction.

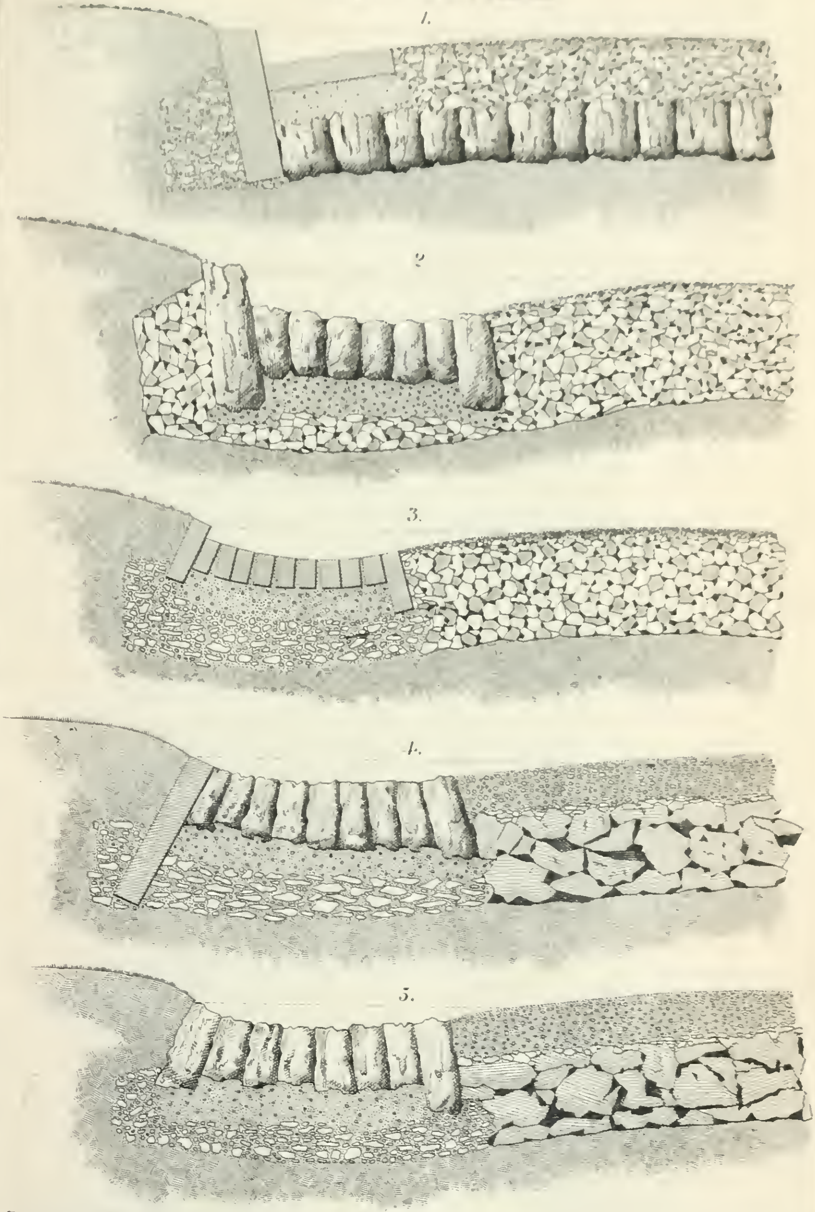
(To be continued.)

NOTE.—Typographical corrections to Chapter I:

Page 101, twelfth line from top, "old" for *odd*.
" 102, twenty-second line from top, "of" for *on*.
" 103, twelfth line from top, "one" for *on*.
" 104, seventh line from bottom, "engineers" for *engineer*.
" 106, second line from bottom, "specialty" for *speciality*.
" 106, bottom line, transpose *quality* and *quantity*.
" 107, seventh line from top, "round" for *rounds*.

* Of this, about two-thirds of a mile was finished with coarse-screened gravel, which will be further mentioned hereafter

ROAD GUTTERS

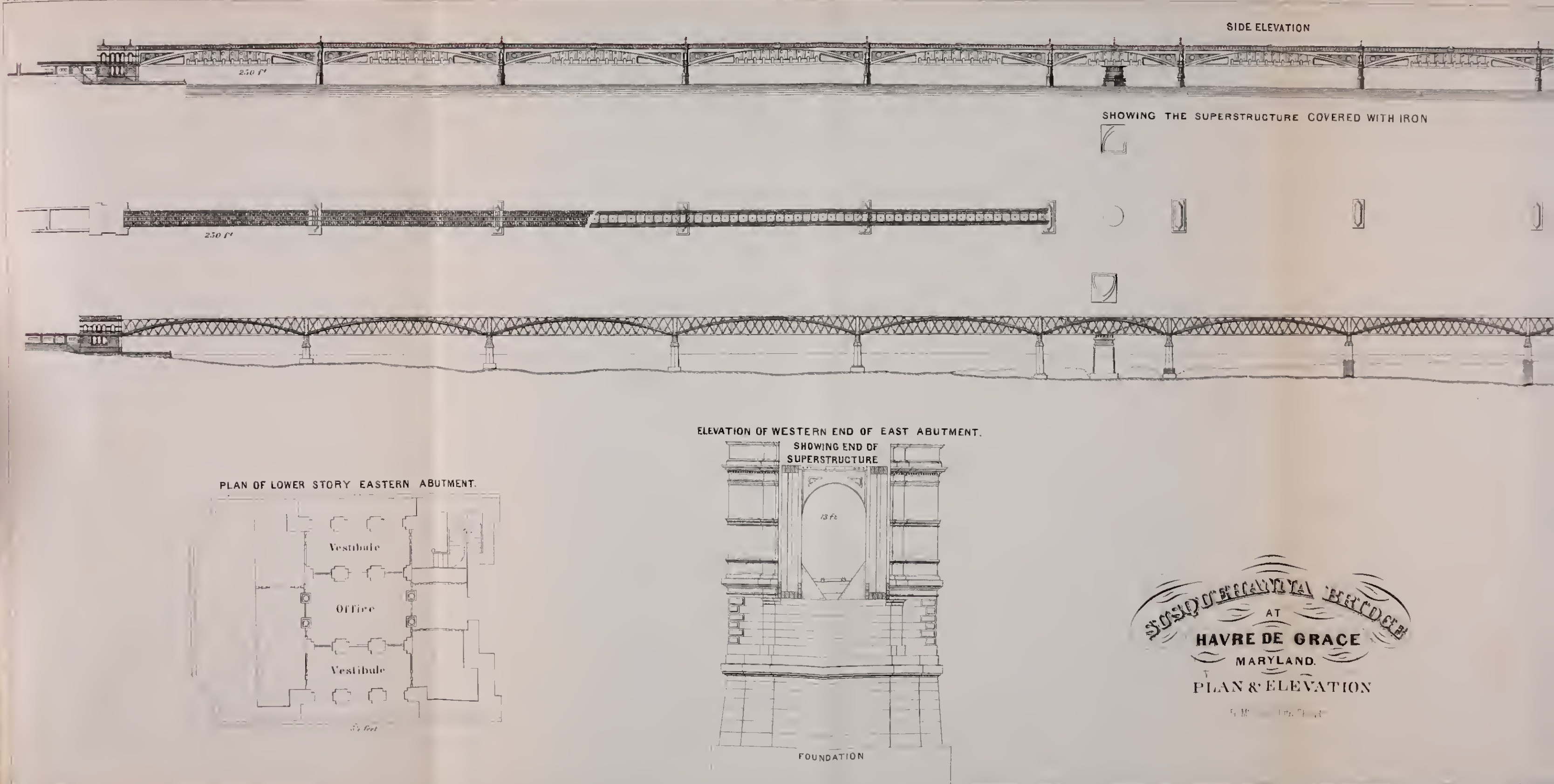


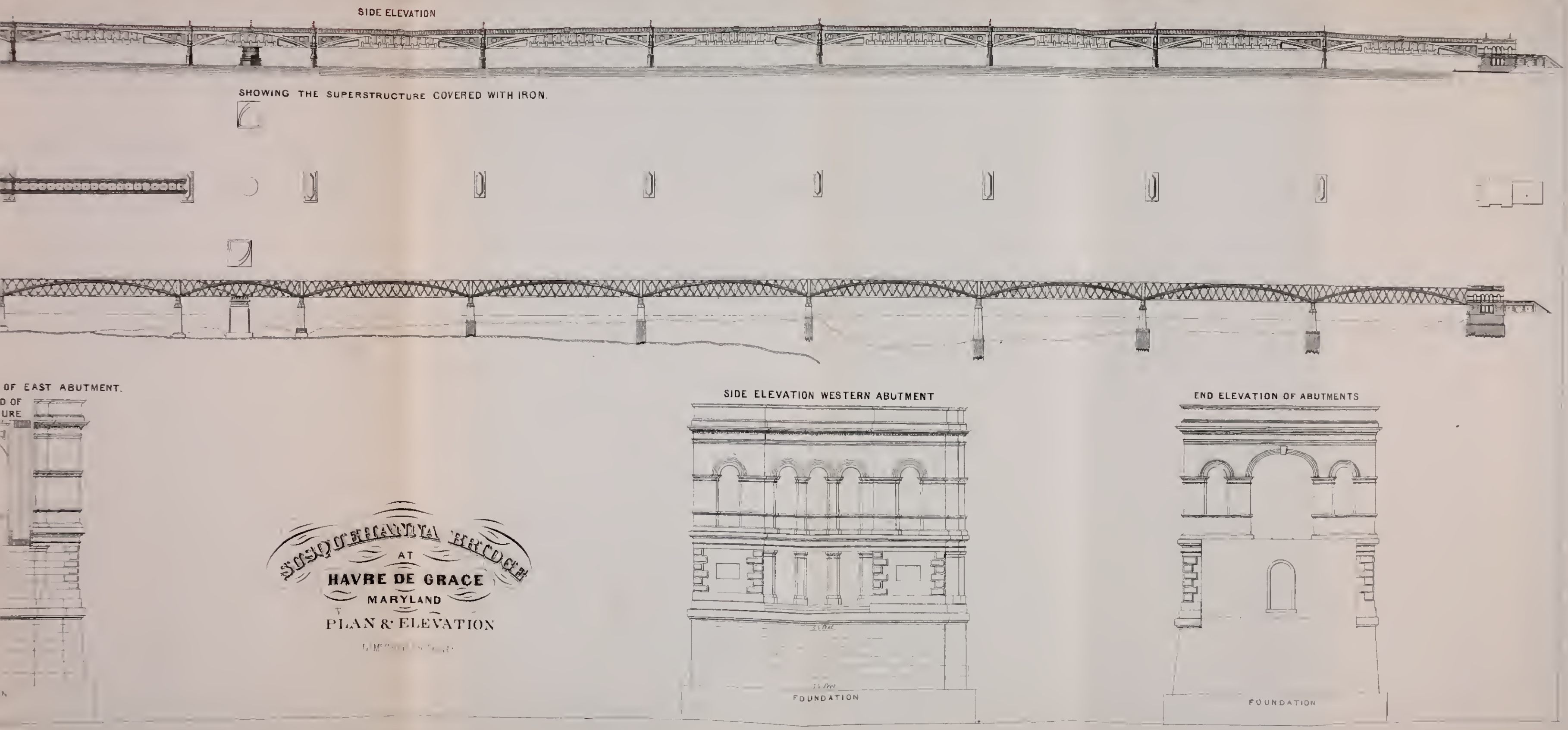
Road No 1. 15" deep, of Telford pavement and McAdam stone. No 2. 15" of McAdam stone. No 3 13" of McAdam stone. Nos 4 & 5 11" of rubble stone and 5½" of gravel.

Gutter No 1 dressed "blue stone." No 2 rough shaped quarry or field stone curb, and cobble stones. No 3. Brick gutter. No 4 blue stone curb and rough shaped quarry stone gutter No 5 all quarry Stones rough shaped.

Scale ½ inch to 1 foot.

H.P. Smith, del.


SIDE ELEVATION
250 ft
SHOWING THE SUPERSTRUCTURE COVERED WITH IRON
250 ft
ELEVATION OF WESTERN END OF EAST ABUTMENT.
SHOWING END OF SUPERSTRUCTURE
13 ft
FOUNDATION
PLAN OF LOWER STORY EASTERN ABUTMENT.
Vestibule
Office
Vestibule
SUSQUEHANNA BRIDGE
AT
HAVRE DE GRACE
MARYLAND.
PLAN & ELEVATION


SIDE ELEVATION
SHOWING THE SUPERSTRUCTURE COVERED WITH IRON.
OF EAST ABUTMENT.
D OF
URE
SUSQUEHANNA BRIDGE
AT
HAVRE DE GRACE
MARYLAND
PLAN & ELEVATION
SIDE ELEVATION WESTERN ABUTMENT
FOUNDATION
END ELEVATION OF ABUTMENTS
FOUNDATION

THE SUSQUEHANNA BRIDGE,

ON THE PHILADELPHIA, WILMINGTON AND BALTIMORE R. R.

Designed by GEORGE A. PARKER, C.E.

IN fulfillment of the promise made to our readers at the beginning of the year, we now present the first of a series of papers containing a full, detailed, and illustrated description of the engineering work named above. Desiring to make this account as complete as possible, we have thought it well to begin with a preliminary Report, prepared by Mr. Parker, for the information of the Directors and Managers of the road, which has never before been published, and which contains many matters of interest to the engineering community. In addition to the topographical chart alluded to in this report, we subjoin a plate, showing the ground-plan of the bridge, its present condition, and its proposed form when covered with a sheet-iron casing, together with elevations of the abutments.

These drawings are intended simply to furnish a *coup d'oeil* of the entire work, as full working drawings of the several parts will be given in future.

Having premised thus much, we proceed to quote the Report just mentioned.

ENG. OFFICE SUSQUEHANNA BRIDGE, P. W. & B. R.R.,
April 15*th*, 1863.

To S. M. FELTON, Esq.,
President P. W. and B. R. R. Co.

Dear Sir: In reply to your late communication in relation to the Susquehanna Bridge, I beg leave to present the following

REPORT.

The great railway thoroughfare between the North and South is broken by the Susquehanna River at Havre-de-Grace, one mile above the Chesapeake Bay, and four below the head of navigation and tidewater.

This interruption to travel between the political and commercial centres of the country, though partially relieved by a ferry of the greatest excellence, has been long felt to be a serious public evil. Whether it could be obviated by a bridge was for many years a

question of great interest with the transportation companies particularly concerned, with the public, and with persons of science who had given it attention. The engineering difficulties were known to be great—they might be insuperable. In 1854, however, after much preliminary examination, an attempt at the construction of a bridge was made in earnest, but circumstances were such in the following year, that the undertaking, for the time, was abandoned. In the spring of last year, 1862, it was thought necessary to take further steps in the matter, and the undersigned was desired to make such professional suggestions as seemed suitable. After reflection, aided by the recollections of former examinations, an outline of a plan of a bridge was prepared and recommended for so much of trial as was possible during the current season. It was thought that the pier most difficult to construct, and most exposed,—the third one, according to the plan, from the eastern shore,—might be built during the summer and fall, and be fully tested during the succeeding winter and spring. It was determined to act upon the suggestion, but not till after it had become too late to hope for the completion of the pier before winter. Nothing more was undertaken, therefore, than the construction of its foundations, which were completed on the 11th of October. There being enough of the season left for the building of a pier in the shallow water, after some hesitation it was concluded to build the fourth one from the shore, where the depth was but eight feet, and the difficulties and risks comparatively slight. The foundations were completed on the 29th of October, and the iron caisson, within which it had been decided to construct the masonry, secured upon them in two days thereafter. On the 28th of November, the masonry was finished to the height of seven feet above ordinary high water. The work of the season then closed. An open winter set in, which has been succeeded by a spring of uncommon mildness. Our work, therefore, has been subjected to none of the tests that had been looked for. There have been no large accumulations of ice at the mouth of the Susquehanna, nor the usual freshets. So far, therefore, not much more has been demonstrated, practically, than the methods used of forming the pile foundations, and constructing solid masonry in ordinary depths of water.

Whether to use the coming season in finishing the experiment with pier three, and waiting for the further tests of another winter, or, accepting the hazards, to adopt definitively the entire plan which has been outlined (if no better offers), and to proceed in its execution

vigorously, is now the question for consideration and settlement. If there were no urgency in the case, the first course might be reckoned the only prudent one; it is but too well known that the demand for this bridge has now become so great, that it may be reasonably questioned whether it will be satisfied with so deliberate a mode of proceeding, if the other prompter course gives even a moderate promise of ultimate success.

To say of any plan of this sort, that it has been prepared with care and deliberation, is but a small recommendation, and the fact that the present one is the result of several years of minute and systematic investigation, made under an almost painful pressure of responsibility, will not therefore be urged as a merit. It must carry with it its own evidences of truth and reasonableness, or it must be rejected, of course. But against casualties incident to construction, it will not be expected that it can furnish absolute guarantees. No scheme of engineering, involving new and untried methods of dealing with natural forces, can do this. It is only by taking advantage of nature's blind side that we prevail against her at any time; and this advantage is dependent upon chance, never at our command, but to be patiently waited for. There is never security from elemental irregularities. Floods, destructive of the costly preparations of months, will come out of season and contrary to normal habits; and the best contrived machinery will fail, inopportunely and disastrously sometimes, in consequence of the bad faith or unskillfulness of artisans. But these contingencies never can be impracticable elements, if their possible cost is not inordinate, and out of proportion. In a succession of seasons, surely some will be found to be propitious and sufficient, and it would be preposterous to expect, at this period, and in this country, a mechanical failure to be repeated on account of imperfect workmanship. Improvements never fail to follow primary inventions that contain a successful principle. These chances of accident, therefore, do not enter into the question of practicability, when their cost is within admissable limits.

What has been devised for this work is believed to be demonstrable scientifically, the commercial element belonging to the case having therein its full valuation, but it is offered, nevertheless, under the conviction that it is not, and cannot be, altogether free from the doubt that always must surround projects of similar nature. Mr. Brunel, while at once the most adventurous and the most invariably

successful of modern engineers, rarely reckoned beforehand upon the unqualified success of any of his schemes. In his report upon the Victoria Bridge at Montreal, made near the close of his life, he observed, with an impressiveness only to be understood by an engineer: "Few of the great difficulties in engineering, resulting from the operations of natural causes, can be entirely overcome, or the result rendered positively certain by any amount of skill or at any cost. The success is at best a question of degree, and what is called certainty, a mere calculation of probabilities; and a certain amount of risk, more or less, still remains, and while this is a strong argument against incurring excessive cost in the execution of a work which, after all, can never insure certainty, it is also necessary to have it in mind, when considering plans which, speaking in general terms, have been found hitherto to succeed,—it is necessary to examine into the degree of that success, and to consider what value has been attached to the amount of risk still remaining in the examples serving as precedents, and what amount of risk it is wise or profitable to run in the particular case under consideration."

And others as well as Mr. Brunel, when compelled by professional duty to assume the responsibility of inaugurating new enterprises of great cost and public importance, have felt, in perhaps equal measure, this pressure of overhanging doubt. Smeaton had misgivings of the Eddystone during the whole progress of its construction, and never once felt sure of its stability till, with his own eyes, he saw it vibrate in a storm. It was only when he knew it would bend and recover that he was sure it would not break. The Menai Bridge was a subject of doubt and misgiving up to the very moment of its ultimate trial. Telford could not be persuaded of its entire success, notwithstanding that his plans had met beforehand every scientific test, till the actual trial had made doubt no longer possible.

These are instances, after all, of doubts that were altogether fallacious, and therefore should not, perhaps, be discouraging. We cannot have the advantage of the skill of any of these eminent men, but our work may certainly expect to obtain the full advantage of any recent improvement in the general science of engineering, and there is no presumption in saying that this is very considerable. The public works of this country and Europe, executed within the last few years, are rife with improvements of all sorts.

The situation in which it is proposed to place the bridge at the Susquehanna, is, as has been stated, one of peculiar difficulty, but the

better these difficulties come to be understood, the less formidable do they appear. They consist principally in the unusual depths of water, the unstable nature of some part of the bottom, and the violence of the currents in freshets, and when charged with accumulations of ice.

The site was fixed in 1853, after a most careful hydrographic survey had determined, that it was the best to be found within the geographical limits which the supposed exigencies of the great thoroughfare, to which the bridge was to be an adjunct, made available. These limits covered only that portion of the river lying between its mouth and the head of Watson's Island.

The choice of exact position lay between three principal routes, which are shown in the accompanying plan and profiles. The southernly route was open to the objection of deeper water, greater difficulty in securing foundations, and more length than was found upon either of the others. The upper one involved a practical division of the bridge into two divergent parts, joined together by a curved embankment over the island. The middle route, however, was not finally selected till after the fullest consideration and most elaborate comparison of relative advantages and disadvantages.

The axis of the position is that of the present location of the P. W. and B. R.R., extended over the river from the eastern bank. It terminates 1600 feet north of the ferry, and is brought in connection with the southern division of the railway by a change of the latter, beginning 3300 feet west of the Havre-de-Grace station.

The river debouches nearly a mile below, though it usually has the appearance of an arm of the bay till it meets the rapids, four miles above. Within these limits it is a basin, having a fall of only two inches from one end to the other. It is divided by an island about one mile in length and five hundred feet wide, which, at the upper end, is composed of high solid rock, protecting it from the wear of the stream, and on the south has a bar projecting downwards nine hundred feet. This bar is crossed by the bridge line near its lower extremity, the river being there divided into two channels. The shores below, upon both sides, are low and quite uniform out to the bay, but around the island they are crooked and higher, and in some places rocky. Above, they are very steep and even mountainous, and nearly everywhere of primitive rock. The tide ebbs and flows here from two to three feet.

The currents are nearly vertical to the line of the bridge, and in

summer have not generally a velocity at the surface of more than a mile and a half per hour. It is somewhat remarkable, that, under certain conditions of the tide, they increase in force towards the bottom. Except in freshets, however, they do not acquire sufficient force to disturb the bed of the stream. Then they become violent, and changes of greater or less magnitude invariably result from their action. In extreme cases, the water at the centre of the channel has been known to move at the rate of twelve miles to the hour—more rapidly than it ever moves in the Missouri or Mississippi. No considerable changes in the normal directions of the currents occur, except when they are diverted by the ice. The ice phenomena here, therefore, become of importance, and require a particular description, a special interest attaching to them beside that merely practical, from the fact that they are the main cause of the prevailing doubts about the practicability of the bridge.

As was stated, the first five miles of the river are, in effect, a basin, essentially under the tidal influence of the Chesapeake Bay. At the mouth, and extending for miles into the bay, there is but a thread of a channel, near the western shore—contracted and sinuous—affording passage for vessels of only nine feet draft. The wash of the stream has deposited here a bar of alluvium, reaching almost to the surface. This basin is not often frozen over deeply, nor ever, till the water has been dammed at the shallows below by the ice. Until this thaws, or is artificially broken up, no movement of the sheet upon the basin can possibly take place; and when one mass thaws, the other necessarily does, removing thereby whatever of danger it might contain. It does happen, however, that the process of dissolution is arrested by intense cold, at times when there may be a steady back-set from the bay, and then the "slush" and broken floating ice unite, causing an excessive rise in the river. If the cold weather then continues, "packing" takes place on the shallows, and extends back to the foot of the rapids. During this process, the currents take eccentric courses, often directly or diagonally across the stream, and if at such times there be a large increase in the flow from above, these currents, charged with broken ice in masses of great depth, look extremely formidable, though, under the circumstances, they really are not so in any degree corresponding to their appearance, as they consume the most of their momentum in their movements against each other. But they cause jams and ice hummocks at different points in the river, and occasionally dam the water at the head of Watson's Island so effectually, as to flood the

town of Port Deposit, two miles above. The rapidly accumulating force of the stream, however, in a few hours, demolishes these obstructions, and reduces the level to the ordinary high water limits. With the ice in the jammed condition which has been described, continued frost is very sure to result in the solidification of the whole mass within the basin. In the winter of 1851–52 a jam occurred which had exactly that result, and a track was built over the river, upon which trains passed for several weeks. In this condition the ice never moves in a mass. With the progress of the season it gradually "rots," disintegrates, and with the first spring floods, moves harmlessly into the bay.

The ice above never passes the lower rapids till the mouth of the river is substantially clear. It then appears too late in the season for severe frosts, and always in small broken masses. These in great freshets are borne down into the bay with immense violence, but, detached as they are, and having no tendency to aggregate, they are like floating logs, not much more powerful than the water itself.

A line of piers stretched across the river undoubtedly may be expected to somewhat change its *regimé.* A sheet of ice covering the whole area of the basin, will naturally break off when melting at the line of obstruction, leaving the piers exposed to the pressure of what remains. The exact mechanical power of such a mass it is not easy to calculate. Under certain circumstances it may be considerable, but as it can never be cumulative, it is easy enough to find its extreme limit. The relation of the force to the weight will be that of the fall to the length. Thus: the length of the sheet of ice being 25,000 feet, its width is 3300 feet, the difference of level between its upper and lower ends 2 feet, its average thickness 1 foot, and its weight per cubic foot 55 pounds, the whole weight will be 4,537,500,000 pounds, and the whole pressure 363,000 pounds, or about 16 tons to a pier. This must be the maximum while the ice remains together. Its effect would, of course, be imperceptible upon a pier having a weight over the line of impact, exceeding three hundred tons. In a rapid thaw it might occur that the sheet within the eastern channel would break off at the head of Watson's Island, and pass out between the piers in a partially melted state, leaving all above and west of it unbroken. The remaining mass, disintegrating, immediately afterwards, would allow of the possibility of somewhat large masses of "rotten" ice passing down through the opened channel against the intervening piers. But these could not exceed 600 feet square, nor a foot in

thickness. The length of the plane of descent might be 4000 feet, and the whole fall 6 inches. Supposing them to move with the water, their greatest velocity would be 5·67 feet per second, and their momentum 93,600 pounds. One-half of this, say 47 tons, might possibly strike a single pier, and if that should happen to be the deep water pier, the pressure of the water and ice together, upon that pier, would be 110 tons—about the one-twelfth part of its inertia.

The bed of the river, on examining it, after reopening the question of building the bridge, last year, appeared to be not much altered at the positions which had been subject to particular observations in 1853, except at the bar, and on the lower shoals, where it was found that the current had silted up the bottom from one to three feet. The profiles referred to, show in detail the slight changes discovered at the line of the bridge. At the points where the soundings were taken, the bottom was bored wherever it was penetrable. For a distance of 1100 feet from the western bank it is shelving rock, with here and there a patch of sand two or three feet deep. East of that it has, first, the usual stratum of river sediment, one to three feet thick, and next a sandy alluvium varying from two to ten feet in thickness, and below this a layer of nearly pure gravel and sand resting upon the primitive ledges of granite. The earthy formation is undoubtedly a deposit of the detritus of the stream, the law governing delta formation being plainly visible in the stratification. As the original mouth of the river—between the Capes of the Chesapeake, perhaps—silted up and receded the purely mineral matter, borne along with the water, settled upon the organic surface left by the attrition of the currents, and on that have subsided the lighter *débris*, in the order of their density. The depth of the underlying rock has not been ascertained eastward of the bar, but its position is of no practical account, since it is known to be too far down to afford support for a bridge. At a point 25 feet beyond the edge of the eastern channel, it is 65 feet below low-water level, and thence it gradually rises to where it begins to form the bed of the river.

That piers could be built at all the points where the rock was found, was plain enough, though at a cost proportionate to the difficulties—certainly very considerable; but where the rock was too remote to be reached by foundation piles, the practicability of building permanent piers could only be determined by actual experiment—by ascertaining if the lower earth stratum that overlie the rock could sustain the necessary weight. Upon this test, therefore, turned the whole question

of the practicability of the bridge, and no time was lost in applying it as thoroughly as was possible, after commencing the investigations of last year. Experimental piles were driven at every doubtful point. The results were variable, but in the main were so favorable as to permit it to be assumed, provisionally, that pile foundations would be available. The shape of the bridge, that is, the form, number and position of its piers, and its superstructure were then considered with reference to the section of the river, at the highest stage of water, to its channels, to cost—both of money and time—and also to the requirements of the charter. To conform to the law, the bridge, as located, should have a pivot-draw at each channel, with openings of 60 feet. The second draw was evidently an evil to be avoided, and fortunately it was found possible to dispense with it, and practically to comply with the charter also, by so locating a single one as to make it serve for both, after opening a new passage-way for vessels above the line of the bridge.

The main current of the eastern channel was found to be about 250 feet wide, and 42 to 52 feet deep. The currents on the western side of the river, where the deepest water was 20 feet, were not confined to particular channels, their force being pretty evenly divided over a width of 800 to 1000 feet. West of the bar, therefore, there was no concentration of force in the water, to anywhere interfere with building. In the "gut" of the eastern channel it was obviously inexpedient to build, even if it were possible or safe.

The shape of the trunk of the river never changed much, the greatest rise ever known being less than six feet above ordinary low-water.

Out of this summary of facts, the first deduction was the necessity for adjusting the bridge to a span of 250 feet over the deep channel. The next was the principle that within that length of span, the total cost, including superstructure, increased inversely with the length; that is, it was found by calculation, using either form of superstructure, that the part of the bridge lying east of the draw, in length about 1800 feet, would cost less, if divided into seven spans of 250 feet each, with seven piers, than the same would cost if divided into nine spans of 200 feet each, with nine piers. No question as to permanent value was here involved, for it was as well known as any other engineering fact, that a superstructure of wood or iron, divided into spans of 250 feet, might be both as strong and as durable as one having smaller divisions.

The timber bridge at Bellows' Falls, in Vermont, upon the line of the Sullivan Railroad, having spans of 250 feet, had been standing since 1850, and had proved as efficient as any of less dimensions, though it had been subject to uncommon trials. The centre deflection, when this bridge was tested by three heavy locomotives, drawing a freight train at a speed of 25 miles to the hour, was nine-tenths of an inch, the permanent set remaining being about one-sixteenth of an inch.*

The advantage to the water-way of these large spans, though not an obvious truth at the first sight, was found to be relatively as great here, where the stream has the unusual width of nearly a mile, and an average depth of more than 22 feet, as in the more common situations of narrower channels and more excessive fluctuations. The general facts pointed to a rigid observance of a primary rule of engineering, restricting obstructions to the flowage to a practical *minimum*, by limiting the number and size of the piers. Provision was to be made for the discharge of all the water of a river of the first class, and the pressure due to increased flow during freshets, must be the same here as it was known to be elsewhere. It had to be considered that in none of the vicissitudes of water flowing in channels, could an increase in volume alone be any reliable index of the quantity in motion, or of its mechanical force. The lower reaches of great rivers were known to be of a nearly invariable section of orifice. The Danube was neither broader nor deeper after receiving the Inn, nor its periodical changes more considerable than those of the Susquehanna. This uniformity of volume under all circumstances had a partial explanation in the main fact, that during floods, and while the swollen rapids were brought even with the connecting planes above and below, submerging the obstructions, which in the common stages operate effectively in neutralizing momentum, a large portion of the particles of water near the rivers' mouth receives the full force due to the total descent of the stream and its affluents. The velocity and pressure were nearly as the whole fall, and the discharge in proportion to the accelerated velocity.

But a more cogent reason for giving to the bays the widest practicable limit, than any to be deduced from these more general facts and considerations, lay in some of the anomalies which the situation dis-

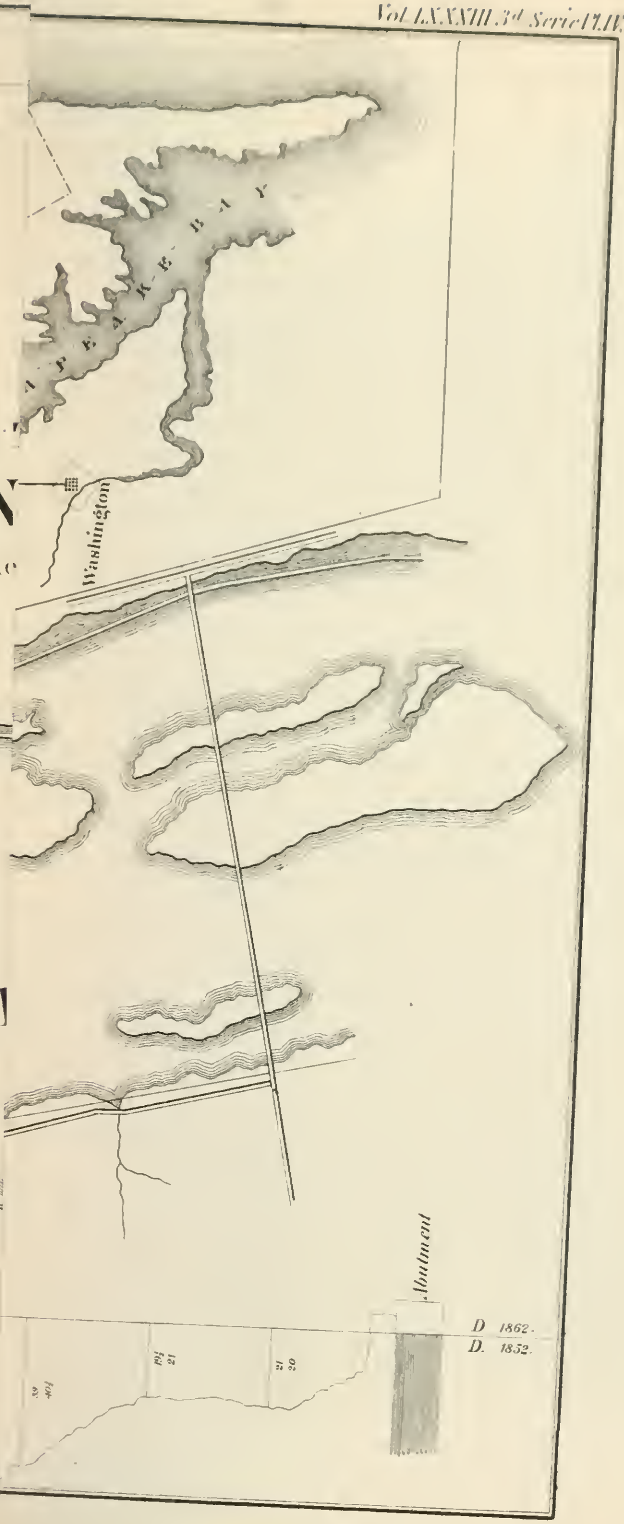
* NOTE.—This bridge was designed and built by Mr. Parker, and was the first timber bridge for a railroad of so long a span, erected in this or any other country. —ED.

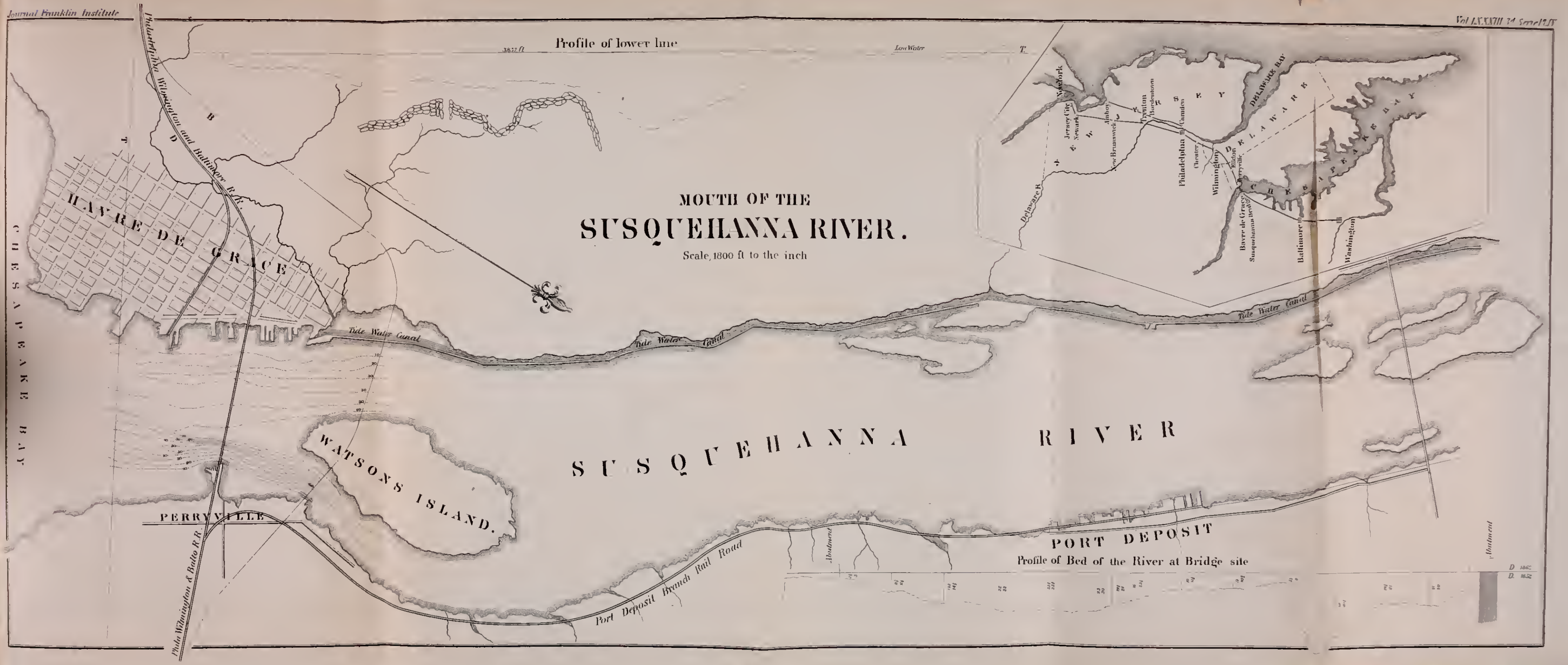
F

N

the

U




MOUTH OF THE
SUSQUEHANNA RIVER.
Scale, 1800 ft to the inch
Profile of lower line
Low Water
HAVRE DE GRACE
CHESAPEAKE BAY
Philadelphia Wilmington and Baltimore R.R.
Tide Water Canal
SUSQUEHANNA RIVER
WATSONS ISLAND.
PERRYVILLE
Phila Wilmington & Balto R.R.
Port Deposit Branch Rail Road
PORT DEPOSIT
Profile of Bed of the River at Bridge site
Abutment
New York
Jersey City
Newark
Amboy
New Brunswick
Trenton
Bordentown
Camden
Philadelphia
Chester
Wilmington
Elkton
Perryville
Havre de Grace
Susquehanna Bridge
Baltimore
Washington
Delaware R.
NEW JERSEY
DELAWARE
DELAWARE BAY
CHESAPEAKE BAY

covered. For instance, the force of the stream there, upon any theory of calculation thought to be applicable, was that due to a velocity under six miles to the hour, while the measured velocity in the centre of the channels was fully twelve miles to the hour at the surface of the water.

The structure having to be of a strictly utilitarian character, art could claim little more of it than a decency of proportion, and as much of symmetry as could be attained without sacrificing economy.

Upon the whole, it seemed to be best to fix the channel span with strict reference to its shape, and the length of that being 250 feet, to make all the other regular spans the same, placing the draw at the point where it would best answer the double purpose required of it. Laying out the work upon this idea, it was found that twelve complete spans of that length, with a draw of 175 feet, brought the ends of the bridge, where abutments were required, sufficiently within the line of existing and permanent projections from the shores, to secure them amply from any possible wash of the river. The site of every pier was exactly determined, carefully surveyed, and, where practicable, tested by piles, driven by a ram weighing two thousand pounds.

(To be continued.)

ON THE IMPROVEMENT OF RIVERS AND HARBORS THROUGH THEIR DELTA.

By D. S. Howard, Civil Engineer.

Water is so nearly a perfect fluid, that it is influenced by the slightest force, whether at rest or in motion. When at rest, a mild wind, if continued, will create a violent oscillation, in the shape of waves or swells. If in motion in a channel, however smooth, the slightest inequality of resistance on the sides will cause a vibratory motion from side to side, with violence proportioned to the velocity of the current, which will also be the measure of a similar motion between the surface and the bottom of the stream. The length of the vibrations indicate, by proportion, the depth as well as the width of the stream.

A combination of these forces, when sufficiently strong to be observed, produce what are called ripples, in small streams,—in larger ones, rapids. The motions are the same in waters of less velocity;

though the surface be smooth, the thread of the stream vibrates from side to side, and from surface to bed, with the same certainty, and with a force in exact proportion to the velocity of the stream.

These laws are also answerable for the formation of "breakers," when the dead swells of a deep sea approaches the shoal or beach; but we need not carry this general discussion further, as the object of the present writing is to illustrate the laws that govern rivers with a plurality of outlets, such as the Ganges, Nile, Danube, Mississippi, &c., which divide their waters through their delta into two or more streams. These streams are, all in their turn, the main outlet. The shortest will, of necessity, have the greatest velocity of current, which not only calls for the largest share of the debris from the upper waters, but creates greater force in the oscillating motions mentioned, which wear away the banks, and form bars and bays, increasing the delta, and otherwise adding to the length of the current, until the velocity is less than that of some other one of the outlets, when the superiority of outflow will be transferred to the shortest and most direct of the other channels, until the same causes, in the course of time, shall have increased the delta in that direction, and in other ways shall have lengthened the current of the stream, when the next most direct outlet comes in for its turn.

The time required for these changes is determined by the age and extent of the delta, and the specific gravity of the material forming it, which indicates its inclination, and the consequent velocity of water required in its formation.

The heavier the material, the greater the velocity required to carry it through; consequently the heaviest will stop short of the outlet in the bed of the river, until the necessary greater inclination is produced, while the lighter part of the drift is spread upon the overflown banks, raising them, in the same proportion, to the same inclination.

A thorough investigation of these laws to a full realization of them, will point directly to the only successful course to be pursued in the improvement of rivers through their delta.

This is a question, to most engineers, never yet satisfactorily settled. None of the usual appliances on channels with permanent banks can be made successfully, such as dams and locks, dykes, levees, &c.

In addition to the great expense of such structures, on so uncertain a foundation, they have a tendency to favor a larger flow through some other channel, which it is the main object to prevent.

When the largest portion of water is permanently secured to the

channel selected for improvement, the others will gradually fill up and become extinct. Therefore, all the efforts made should be to shorten and enlarge the one we wish to improve, by straightening and removing all obstructions to an easy flow to the outlet.

The straightest channel, through the same extent of delta, will be the shortest, and the shortest will give the greatest velocity to the water, which, with a little assistance, will scour it out to a capacity sufficient to cause the waters of the upper stream to seek the improved channel, for the shortest and easiest way to reach their destination.

No attempt should be made to force the water into the improved channel, which should be constructed with an uniform bed, low enough to require no other force than that of gravity, to bring the water through it. There is no foundation by which any other force can be made available in the deltas of rivers.

The piers or jetteys at the outlet for the harbor, if any be required, should not contract the channel so as to prevent the sea-level from setting as far up the channel as possible, as the velocity of the current is a measure of its length. They should only be fitted to prevent the coast winds from filling the channel with material from the beach. They should extend into water so deep, that no ordinary swell should ever reach the bottom with force enough to disturb it, and only near enough together to prevent the coast winds from getting up a sea between them. Then, if a uniform channel through the outer bar be made, of the same depth as the water inside, and an ample breakwater be placed at a proper distance from the piers, to prevent the direct sea winds from creating swells between them, calculated to precipitate the sediment before it leaves the channel, no deposit of much consequence from the river will stop short of deep water.

The situation of the outlet may be such that but one jettey will be required. When the prevailing winds are coastwise, or a little inclined, and the surface currents correspond, as at the mouth of the San Juan Del Norte, Nicaragua, one jettey on the windward side is better than two, particularly if there be a curve in the coast, forming a fair lee shore, a proper distance from the jettey, which should be extended at right angles, or nearly so, to the prevailing winds, and terminate in deep water.

The length of the jettey should be proportioned to the distance from the lee shore, and so situated as to form a centre for the first motion of an eddy, caused by the winds and current, assisted by the under-tow from the lee shore and the outflow of the river, with the re-

sistance of the jettey, by all which a resultant force will be created, that will scour out a channel along the side of the jettey, and leave all deposits at the end, in a direction determined by these combined forces.

There is but one thing more to complete the permanent improvement of the river and harbor. This is the control of the freshets, by reservoirs at the headwaters, which is sometimes the cheapest way to begin the improvement, for by this means, nearly all the material for bars is left in the bed and on the banks of the upper waters.

The only objection to the reservoir system is the necessary overflowing of land, but this objection is generally more than balanced by rescuing more valuable lands from inundation by freshets, to say nothing about the destruction of other property, and sometimes human lives as well.

A partial control is better than none. Sometimes a very small expense will control a large amount of water; for example, by damming the outlets of small lakes, very common at the headwaters of most large rivers—making the spilling way very narrow and the abutments very high—thus requiring the lakes to rise much higher than usual, without a sufficient discharge to create a freshet. Such reservoirs are very useful, without gates or attendants, or any supervision whatever.

San Juan del Norte, Nicaragua, March 12, 1867.

From the London Engineering, No. 62.

THE FLORIDA AND CUBA CABLE.

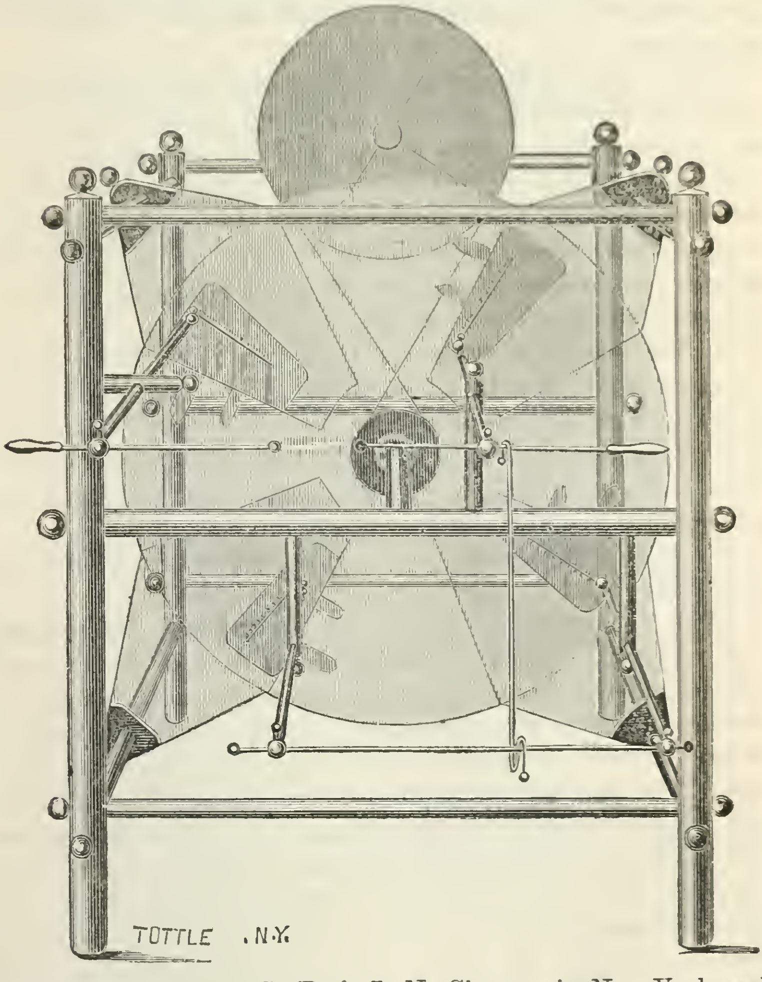
The India Rubber, Gutta-percha and Telegraph Works Company (Messrs. Silver & Co.) are at present manufacturing a cable for submergence between Florida and Cuba. The length of the cable is one hundred and ten miles. The conductor weighs one hundred and seven pounds to the nautical mile, and is insulated with one hundred and seventy pounds of gutta-percha. The core is served with hemp in the usual way, and is covered with twelve No. 9 galvanized iron wires. The complete cable weighs about two tons to the nautical mile. This is, we think, the first instance where a cable of anything like this length, and having a gutta-percha core, has had the core manufactured and the iron wires applied on the same premises, thus saving the risk attendant on the transport of the core from one factory to another. The small weight of this cable is another instance showing that the Americans are still learning the lessons as to the life of cables, which have been learnt at such cost by our own large submarine telegraph companies.

Mechanics, Physics and Chemistry.

AN IMPROVED FORM OF THE HOLTZ MACHINE.

By Charles T. Chester, Esq.

We give below a drawing of a Holtz Machine which has just been constructed and put in operation most successfully, by Mr. C. T.



Chester, of the firm of C. T. & J. N. Chester, in New York, well known as extensive manufacturers of all apparatus used in telegraphy.

The novel features in this machine, and those which give it special efficiency and convenience in use, are the following:

1st. With the exception of the rotating plate and sectors, the whole instrument is made of vulcanite and brass.

By this means, every part may be made with perfect precision and great strength and firmness; while in the original instrument, many parts being made of glass rods and of wood, there was great want of accuracy in adjustment, and that general *shackly* condition inseparable from the use (in a complicated machine) of such a material as glass, which is at once easy to break and difficult to shape into the desired form.

2d. The paper inductors are supported on spear-shaped plates of glass, each of which is separately adjustable as to its distance from the revolving plate and its angular direction, and may be replaced with great facility in making experiments. This is a great advantage over the large and delicate plate with its five openings, used in the original machine, where no change was possible in the individual inductors, and a fresh plate (very costly and difficult to prepare) was required for each new combination.

3d. The junction of various parts is effected by strong-threaded rubber screws, so that in a few minutes the machine can be taken to pieces, or a single portion may be removed without disturbing the rest. So far was this from being the case with the original instrument, that a very slight alteration sometimes involved the entire disconnection of the whole instrument.

In regard to the performance of this machine, Mr. Chester writes as follows:

"Only one set of sectors have been tested with this instrument, with very good results. Several different sized tubes are used for condensers—the larger sizes have given the best results, as the machine develops much quantity. Very voluminous sparks are flashed between the buttons when separated between three and four inches, but when in best condition, the sparks leave one of the buttons and spring to a portion of the condenser, five to six inches, and alternating with these long sparks in air, many flashes between seven and eight inches, spring within the condensers or upon their surface. Several new sectors are in course of preparation, and will be compared with the originals. No insulation has seemed necessary since the first. No weather has thus far prevented the operation of the machine.

"The original Holtz machine, which was in my possession for some

time, was so arranged as only to work by uniting the two positive and the two negative collectors. This arrangement gives a good result with this American machine, but it is far exceeded in brilliancy by the connection of three collectors against one. The machine seems capable of a much higher development."

PROPOSED CHANGES IN THE HOLTZ MACHINE.

We translate from the *Comptes Rendus*, of January 7th, a portion of the remarks made by M. de Parville at a meeting of the Academy of Sciences held on that date.

"I now have the honor of submitting to the Academy, a new arrangement of electric generator which I have just devised, but for which I ask permission to date from to-day."

"In all apparatus before described—in the machine of M. Holtz—in the electrophorus of M. Piche, the disc induces equal quantities of electricity in equal times, and the discharges being continuous, the tension remains the same after each turn of the handle."

"When the inductor polarizes the electricity imperfectly, or when the hygometric condition of the air hastens the loss, the machine, after a certain time, will not work, or, in fact, in all cases the tension on the collectors decreases if you do not renew the discharge."

"I propose to make an electrophorus with inverse properties, that is to say, working with a substance which is partially isolating, and in which the tension, instead of diminishing, augments proportionally to the turns of the wheel. At each revolution of the disc, the machine multiplies its first charge, and the tension is only limited by the loss which results from different parts which diffuse electricity in damp air, agreeing very nearly with Coulomb's law."

"This is my arrangement:

"A disc of material, which is not a good conductor, is adjusted to turn on an isolated axle, before two half-plates, which are distinct and separate, allowing the axis of rotation to pass between them. Before the disc are placed comb collectors terminating in balls which collect different kinds of electricity."

"The plates of isolating substance, which are partly covered by conducting plates, serve as inducing elements, as the stationary plate

of M. Holtz or the sectors of M. Piche. Each of them has in its centre, and perpendicular to its plane, a metallic handle terminating in a comb. At a short distance from these combs, and supported on the same prolonged axis of rotation, turns a second disc, similar to the first, before two different plates, equally distinct and separate. Finally, the balls of the collectors are respectively connected by metallic wires with the two last plates."

"It is only necessary to give a rapid rotary motion to the axle of the machine; when it is so arranged a continuous jet of powerful electricity should continually flash between the poles of the collectors."

"You can electrify one of the inductors. However, according to Faraday's theory, the two inductors finally electrify themselves directly, by the intervention of the middle moving part. The movable disc receives contrary electricity, and the collectors are charged."

A mathematical discussion of the subject, which we do not think likely to interest our readers, here follows, after which—

"It is then seen that in this condition the inductor would not fail to polarize the electricity, the multiplying discs would be constructed of partially isolated material, the machine would not be less charged, and the longer it was worked the better it would become. The experiments which we have made with an imperfect model give us these results."

Some remarks of a controversial rather than scientific character, here follow, which we do not think it worth while to reprint.

Ed.

AN IMPORTANT ADJUNCT TO THE INDUCTION COIL.

By Henry Morton, Ph.D.

The use of Leyden batteries with the Induction Coil seems to me not to have received the attention which the subject deserves. The enormous quantity of electric force set in motion by this machine, and the splendid effects produced, (especially in the eyes of the operator, who is moderately near the apparatus,) have probably diverted attention from those means which might be enlisted for yet greater development of these effects.

The requirements of lectures delivered in large buildings have, however, led me to study those means by which the most brilliant effect

possible might be secured to various experiments, and as the results obtained have, to the best of my knowledge, never as yet been published, I proceed to put them on record for the benefit of all who may be interested in the subject.

As a starting point, I would remark that, as is well known to all, the introduction of a Leyden jar into the secondary circuit of the Coil, shortens the spark and increases greatly its brightness. This increase of brightness is due to the concentration of the entire discharge into a single and instantaneous spark of intense temperature, as shown in the spectrum investigations of Plucker. It might, therefore, be expected that the light obtained by this discharge would be richer in actinic rays than that developed by the unaided coil, even if its luminous character was (by reason of diffusion in rarified gases, or the like,) but little increased. These actinic rays, however, are exactly those which develop the beautiful phenomenon of fluorescence; hence, we ought, by the addition of a Leyden jar, to increase, in a marked manner, the beauty of experiments in which this fluorescence plays an important part. The first instrument tried with this view, was the Electric Egg of Canary glass, made by Mr. Ritchie, of Boston, and which, within a range of twenty feet, is so beautiful an object, even with the simple current. It was found that the fluorescent light of a rich emerald green from the glass vessel (18 inches in height by 7 inches in diameter) was at least doubled by the use of a jar; though the flame-like discharge within, showed little increase in brightness, suffering, however, a change in color, from peach color to pink, with a diminution of the blue glow on the negative pole.

To secure the action described above, it is necessary to make some break in the circuit beside that in the exhausted vessel; as otherwise, the discharge would take place so readily that the fluid would not accumulate in the jar, and thus acquire volume and concentration.

The above arrangement has, without doubt, been used by many; in fact, I find, on inquiry, that Professors Robert E. Rogers and John F. Frazer, of this city, have both employed it. As, however, I also find others who have not so done, and do *not* find any notice of it even in works treating especially on the Induction Coil, such as Du Moncel's book of 400 pages, (Notice sur l'Appareil d'Induction Electrique de Ruhmkorff,) and Noad's 'Inductiorium' of 109 pages, I have thought it best to give the foregoing description.

The arrangement above recorded, though entirely satisfactory in the case named, is limited in its sphere of application by the reduced

length of the spark. Thus, with the apparatus I possess, whose spark length is 8 inches, no discharge can be obtained in an Aurora tube of 5 feet, when the jar is introduced. So, also, with the longer Geissler tubes, whose spiral passages develop a length of some feet.

To overcome this difficulty, resource was had to the following expedient: Several jars were arranged so as to be charged by cascade. This plan was first devised by Benjamin Franklin, to save labor in charging a large battery, and is mentioned in his Philosophical Essays, as well as by many others who have written since; among whom Mr. Boggs seems first to have pointed out that the spark length was in this way greatly increased. *Silliman's Journal*, II., 7. 418.

In the case of the coil I find, that, while sparks of but one inch are obtained with a single jar in connection, six jars arranged for "cascade" increase the striking distance to 4 inches.

By this means, therefore, the difficulty as to spark length may be overcome, but not with convenience, as few things could be more unwieldy and fragile than such a combination of jars. I had, therefore, resource, at once, to a battery of plates identical in principle with that described by Franklin in the essay before quoted, but differing in detail of construction, and in various appliances.

The simplest way to make such an arrangement is to procure a photographic negative box, capable of holding two dozen 8 by 10 inch plates. (This is the minimum size for an 8-inch coil.) Place in the grooves provided in this box, 8 plates of glass, (8 by 10 inches,) having sheets of tinfoil, 6 by 8 inches, with rounded corners, pasted upon each side. The plates should be equally spaced, and about $\frac{3}{4}$ inch apart. Then connect the adjacent coatings of successive plates by balls of rough paper wrapped with a strip of foil, and pass a copper wire, enclosed in a glass tube, through the lid of the box at each side, so as to make connection with the outside coatings of the extreme plates. These terminal wires being connected with the coil, sparks of $5\frac{1}{2}$ inches are easily procurable, and are characterized by the white light and loud report peculiar to the Leyden jar discharge.

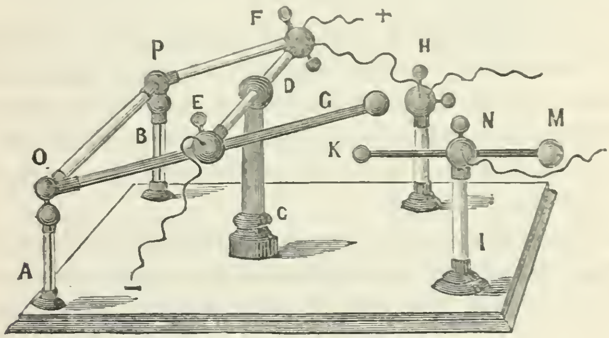
With such an apparatus, all the usual vacuum experiments are easily managed, and the beauty of most, wonderfully increased. Thus the Aurora tube, in place of showing a stream of light half an inch wide, is *filled* throughout its length and diameter of three inches. The large goblets of Canary glass supplied by Mr. Ritchie, for the cascade experiment of Gassiot, eight inches high and six inches across the bowl, in place of shining faintly, with a dark green, almost

invisible, at thirty feet seem so luminous as to be opaque with their own light, like white-hot glass, and give an emerald color, which is even brilliant at a distance of fifty feet.

So with other similar experiments. With the Geissler tubes of small diameter, however, this apparatus produces no improvement, but rather a loss of effect. The small size of the passage seems to occasion a resistance (due to induction in the material of the tube) which it requires time to overcome, and against which, therefore, this instantaneous flash acts at a disadvantage.

To throw the *battery* above described, in and out of connection, and at the same time make the required changes in the continuity of the circuit, the following plan has been found very convenient.

The base-board in the figure represents the top of the box containing the *battery;* A and B represent the terminals of this battery,



being connected with the outside coatings of the extreme plates, by wires inclosed in the supporting tubes. The frame F P O E G, consists of brass rods and balls, F P and O G, and of cross-pieces, P O and F E, of vulcanite or glass, of which F E turns with friction in the wooden upright, C D. By this means the balls, O P, may be put in contact with the battery terminals, as in the cut, or raised from them. The caps H and N, on glass supports, hold wires leading to the apparatus to be exhibited, while the wires from the coil are attached at E and F; F and H are also permanently connected by a flexible wire.

When the ends of the frame are depressed, as in the cut, and the *battery* is consequently in connection, a break in the circuit to the apparatus is introduced, between G and K. This can be regulated as to its amount, by sliding K M through N.

When, however, the connection with the battery is broken, by

raising O P from A B, G comes in contact with K, and the connection between coil and apparatus is rendered perfect.

I find a *battery* of greater surface, more effective with large experiments than that described before. Its construction is, however, identical with the former, except that glass plates eleven by fourteen inches, with tin-foil coatings eight by eleven inches, set one inch apart in a box of the required size, are employed.

There is another point in connection with the coil and Leyden jars, which is of great importance to experimenters in electricity, namely, that all the ordinary experiments in attraction and repulsion, the chime of bells, sportsman and birds, electrical umbrella, orrery, flyer, &c., may be operated with perfect ease, by connecting the apparatus in question with a Leyden jar or battery, and then charging this latter as usual, with the coil; that is, by connecting the outer coating with the negative pole, and throwing sparks from the positive pole at the knob.

This seems so simple a plan, that I hesitate to mention it as a novelty, though I find no word to this effect in any of the many books which describe the experiments that can be performed with the coil, or in the catalogues of manufacturers, who would hardly omit so important a feature, and so strong an inducement to purchasers, if they were aware of the fact.

Others, however, may, like myself, until lately, have been prevented from trying, by the general impression that nothing was to be done in this direction, and if so, will be profited by the suggestion.

From the London Mechanics' Magazine, January, 1866.

ON SOUNDING AND SENSITIVE FLAMES.*

By Professor Tyndall.

The sounding of a hydrogen flame when enclosed within a glass tube was, I believe, first noticed by Dr. Higgins in 1777. The subject has since been investigated by Chladni, De La Rive, Faraday, Wheatstone, Rijke, Sondhauss and Kundt. The action of unisant sounds on flames enclosed in tubes has been investigated by Count Schaffgotsch and myself. The jumping of a naked fish-tail flame in response to musical sounds was first noticed by Professor Lecomte at a musical party in the United States. He made the important observation that the flame

* Read before the Royal Institution of Great Britain, January 18th, 1867.

did not jump until it was near flaring. That his discovery was not further followed up by this learned investigator was probably due to too great a stretch of courtesy on his part towards myself. Last year, while preparing the experiments for one of my "Juvenile Lectures," my late assistant, Mr. Barrett, observed the effect independently; and he afterwards succeeded in illustrating it by some very striking experiments. With a view to the present discourse, and also to the requirements of a forthcoming work on sound, the subject of sounding and sensitive flames has been recently submitted to examination in the laboratory of the Royal Institution. The principal results of the inquiry are embodied in the following abstract:

Pass a steadily-burning candle rapidly through the air, you obtain an indented band of light, while an almost musical sound, heard at the same time, announces the rhythmic character of the motion. If, on the other hand, you blow against a candle flame, the fluttering noise produced indicates a rhythmic action. When a fluttering of the air is produced at the embouchure of an organ-pipe, the resonance of the pipe reinforces that particular pulse of the flutter whose period of vibration coincides with its own, and raises it to a musical sound. When a gas-flame is introduced into an open tube of suitable length and width, the current of air passing over the flame produces such a flutter, which the resonance of the tube exalts to a musical sound. Introducing a gas-flame into this tin tube three feet long, we obtain a rich musical note; introducing it into a tube six feet long, we obtain a note an octave deeper—the pitch of the note depending on the length of the tube; introducing the flame into this third tube, which is fifteen feet long, the sound assumes extraordinary intensity. The vibrations which produce it, are sufficiently powerful to shake the pillars, floor, seats, gallery and the five or six hundred people who occupy the seats and gallery. The flame is sometimes extinguished by its own violence, and ends its peal by an explosion as loud as a pistol shot. The roar of a flame in a chimney is of this character: it is a rude attempt at music. By varying the size of the flame, these tubes may be caused to emit their harmonic sounds.

Passing from large pipes to small ones, we obtain a series of musical notes, which rise in pitch as the tube diminishes in length. This flame, surrounded by a tube $17\frac{7}{8}$ inches long, vibrates four hundred and fifty-nine times in a second, while that contained in this tube, $10\frac{5}{8}$ inches long, vibrates seven hundred and seventeen times in a second. Owing to the intense heat of the sounding column, these numbers are greater than those corresponding to organ-pipes of the same lengths sounding in air. The vibrations of the flame consist of a series of partial extinctions and revivals of the flame. The singing flame appears continuous; but if the head be moved to and fro, or if an opera-glass, directed to the flame, be caused to move to and fro; or if, after the method of Wheatstone, the flame be regarded in a mirror which is caused to rotate, the images due to the revivals of the flame, are separated from each other, and form a chain of flames of great beauty.

With a longer tube and larger flame, by means of a concave mirror, I can project this chain of flames upon a screen. I first clasp my hand round the end of the tube, so as to prevent the current of air which causes the flutter from passing over the flame. The image of the flame is now steady upon the screen before you. I move the mirror, and you have this continuous luminous band; I withdraw my hand; the current of air passes over the flame, and instantly the band breaks up into a chain of images.

A position can be chosen in the tube at which the flame bursts spontaneously into song. A position may also be chosen where the flame is silent, but at which, if it could only be started, it would continue to sound. It is possible to start such a silent flame by a pitch-pipe, by the syren or by the human voice. It is also possible to cause one flame to effect the musical ignition of another. The sound which starts the flame must be nearly in unison with its own. Both flames must be so near unison as to produce distinct beats.

A flame may be employed to detect sonorous vibrations in air Thus, in front of this resonant case, which supports a large and powerful tuning-fork, I move this bright gas-flame to and fro. A continuous band of light is produced, slightly indented through the friction of the air. The fork is now sounded, and instantly this band breaks up into a series of distinct images of the flame. Approaching the same flame, towards either end of one of our tin tubes, with the sounding flame within it, and causing it to move to and fro, the sonorous vibrations also affect the breaking up of the band of light into a chain of images. In this glass tube, 14 inches long, a flame is sounding; I bring the flat flame of a fish-tail burner over the tube, the broad side of the flame being at right angles to the axis of the tube. The fish-tail flame instantly emits a musical note of the same pitch as that of the singing-flame, but of different quality. Its sound is, in fact, that of a membrane, the part of which it here plays.

Against a broad bat's-wing flame I allow a sheet of air, issuing from a thin slit, to impinge. A musical note is the consequence. The note can be produced by air, or by carbonic acid; but it is produced with greater force and purity by oxygen. The pitch of the note depends on the distance of the slit from the flame. Before you, burns a bright candle-flame; I may shout, clap my hands, sound this whistle, strike this anvil with a hammer or explode a mixture of oxygen and hydrogen. Though sonorous waves pass in each case through the air, the candle is absolutely insensible to the sound; there is no motion of the flame. I now urge from this small blow-pipe a narrow stream of air through the flame of the candle, producing thereby an incipient flutter, and reducing the brightness of the flame. I now sound the whistle; the flame jumps visibly. Matters may be so arranged that when the whistle sounds, the flame shall be either almost restored to its pristine brightness, or that the amount of light it still possesses shall disappear. Before you now burns a bright flame from a fish-tail burner. I may, as before, shout, clap my hands, sound a whistle or strike an anvil;

the flame remains steady and without response. I urge against the broad face of the flame a stream of air from the blow-pipe just employed. The flame is cut in two by the stream of air. It flutters slightly, and now, when the whistle is sounded, the flame instantly starts. A knock on the table causes the two half-flames to unite and form for an instant a flame of the ordinary shape. By a slight variation of the experiment, the two side-flames disappear when the whistle is sounded, and a central tongue of flame is thrust forth in their stead.

Passing from a fish-tail to a bat's-wing burner, I obtain this broad steady flame. It is quite insensible to the loudest sound which would be tolerable here. The flame is fed from this gas-holder, which places a power of pressure at my disposal unattainable from the gas-pipes of the Institution. I turn on more gas: the flame enlarges, but it is still insensible to sound. I enlarge it still more, and now a slight flutter of its edge answers to the sound of the whistle. Turning on a little more gas, and sounding again, the jumping of the flame is still more distinct. Finally, I turn on gas until the flame is on the point of roaring, as flames do when the pressure is too great. I now sound my whistle; the flame roars and thrusts suddenly upwards eight long quivering tongues. I strike this distant anvil with a hammer, the flame instantly responds by thrusting forth its tongues.

(To be continued.)

From the London Engineering, No. 62.

THE MACHINERY OF IRON-WORKS.

THE machinery of iron-works, although it has received some improvement of late years, still stands greatly in need of emendation. The whole of the Bessemer apparatus, whether the blowing engines, the hydraulic cranes or in any other part, is extremely well contrived, and reveals the hand of a competent mechanic. So, also, the machine for rolling wheel tires is a very creditable instrument, and the Nasmyth hammer, or its imitations, is a great improvement upon the old tilt. But even the effect of the Nasmyth hammer is too topical in the case of large masses of iron, and just inasmuch, as we have pointed out in another article, that in pile driving the effect of a rapid blow is rather to shatter the head of the pile than to drive it; so in a large mass of iron, a similar blow will only act on the surface without penetrating to the heart. An hydraulic squeezer, or, if we like the term better, an hydraulic hammer, acting more by pressure than by impact, would probably be found better than any existing hammer, or the same end might be attained as in the riveting machine by employing a very short cylinder with a very large diameter, but in such case either the cylinder or the anvil would require to be adjustable to suit different

thicknesses of forgings. In the hydraulic arrangement the same end would be attainable by making the cylinder of the ordinary length, and by propelling the piston only through a small portion of the stroke, whether that portion was near the top or the bottom. But in a steam hammer it would not be possible to do this without a waste of steam.

There is another ground of preference for an hydraulic squeezer over a common steam hammer, in the fact that it would not consume power by shaking the earth and houses in the neighborhood, which may, in some cases, be a serious annoyance, and which cannot be done without an expenditure of coal. Nor is it in the hammers alone that the hydraulic principle might be beneficially introduced, as it could also be employed to propel and reverse the rolls of the rolling mill. Even in the best works there is no visible improvement in the rolling mill during the present century, and it is still a very rude and imperfect instrument, and involves the use of too much manual labor. It would be quite practicable to introduce arrangements whereby rolled objects of whatever weight, would be received and delivered complete, without the interposition of manual labor at all, and this, especially in the case of heavy articles, would bring a considerable saving in the manufacture.

From the London Engineering, No. 62.

HUGON'S GAS ENGINE.

Messrs. Thomas Robinson & Sons, of Rochdale, have taken up the manufacture of Hugon's patent gas engines, and have just set the first engine to work on their premises. This engine has been imported from France; it works by explosions of gas mixed with air in a cylinder. The principal difference between it and the Lenoir engine consists in the mode of igniting the mixture. The Hugon engine effects this by carrying a flame of gas into the cylinder by means of a kind of slide-valve which has a gas-jet in each of its ports. The flame in the ports is extinguished by each explosion, and requires to be re-ignited for each stroke of the piston. This end is attained by bringing the slide-valve with its port in contact with a fixed gas-burner from which the jet in the port is ignited. There are two ports, one for each end of the cylinder, and accordingly there are two fixed gas flames placed opposite to the two openings in the slide-valve containing the traveling jet. The machine in its present state is encumbered with a considerable amount of complication, and in many respects requires the finishing touch of a practical engineer before it may be considered an accomplished fact. With regard to this there can be no doubt, that it is now in as good hands as need be wished for, and it will undergo a thorough reconstruction before it will be introduced into the general market.

(Continued from page [illegible].)

LECTURES ON VENTILATION.

Delivered before the Franklin Institute, by L. W. Leeds, Esq.

Let us illustrate this by a simple experiment. Here we have a very small tube, in which we place a lighted candle, occupying nearly the entire space—this burns brightly, you see.

Fig. 1.

Fig. 2.

Here we have another glass chamber, much handsomer and twenty times as large; we also place a similar candle in it, that burns with equal brightness, but watch them both for a few moments—see how rapidly this light in the large chamber diminishes in size.

That represents, in a beautiful manner, the diminished force of your life in an air-tight room. There it goes—entirely extinguished by foul air in so short a time, but the other continues to burn just as brightly as when first lighted. The smaller one had the window open, so to speak; we will imagine the candle in the large chamber to be a consumptive patient who thought the room so large he did not need the windows open. Remember, therefore, that no matter how small your room is, if there is a constant circulation of fresh air through it, the lamp of your life will burn brightly; but if ever so large and air-tight, your life will soon be extinguished.

Instead of avoiding the cholera by avoiding fresh air at night, the experience of the last summer seems to have taught us just the contrary; for whilst most physicians admit that they are still unable to explain satisfactorily, the cause or remedy for this most mysterious disease, that has within a lifetime carried its fifty millions of victims from time to eternity, they almost universally believe it is a foul air poison, and they have as yet found no surer prevention than pure air.

One of the most striking illustrations of this, and perhaps one of the most wonderful cures of cholera on record, was that of the New York Workhouse on Blackwell's Island. It lasted only nine days, but in that brief period one hundred and twenty-three out of eight

hundred inmates died. I visited the building with Dr. Hamilton, on the third day after its appearance, but the hospital then contained sixty or seventy patients, and some twenty-five or thirty had died within twenty-four hours.

Dr. Hamilton attributed the rapid propagation and fatality of the disease, after it once had gained admission, mainly to confinement and crowding. It was observed that the cholera was confined, for several days, among the women; the women had the smallest apartments, were most crowded in their cells, and with few exceptions, were employed within the building, in close contact with each other during the day. The men were employed mostly in the quarries and out of doors.

The doctor's prescription on that occasion is worth studying. It is very short and simple, however.

A slight change was made in the diet; disinfectants were used; fifteen drops of the tincture of capsicum with an ounce of whisky, as a stimulant at night, was all the medicine given to each individual. But the great means the doctor relied upon for success, was pure air all the time. They were kept out of doors from morning until night, and all the windows were kept open night and day; and although in the hot weather of summer, fire was made in the wards, to insure more perfect ventilation. In six days after the initiation of these simple hygienic measures, the epidemic entirely disappeared.

The disorders and sickness caused by the too rapid chilling of the unprotected body after sundown, have given rise, I have no doubt, to that erroneous popular prejudice so common among all classes, even those of education and ordinarily good common sense, who imagine there is some peculiar poison or source of unhealthiness in the air at night, that is not contained in the air in the day-time. It will no doubt greatly relieve the minds of these from such "vain terrors," and prove most conclusively the entire fallacy of such reasoning, to examine these tables again. In the copies I have made, I have not classified the results given by day and by night, but a careful examination in detail, fails to show any appreciable difference in the aggregate, by day or by night.

Méné's numerous experiments on the air in Paris, gave less carbonic acid at night than in the day-time.

Lewey's analysis on the Atlantic ocean, one thousand miles from the coast, gave a decided excess in the day over that of the night.

He attributes this to the action of the sunlight upon the ocean liberating the gases which it holds in solution.

In cities there is a much larger quantity given off from burning coals of factories in the day-time than at night.

It is not improbable, however, that the more rapid evaporation of moisture towards evening may carry with it the volatile particles of corrupted animal and vegetable matter to an extent slightly in excess of that which occurs in the morning, but it is believed these would not equal the greater contamination from burning coals, and the usually greater stillness of the air, producing partial stagnation, so that the air would be a little nearer pure at night than in the day-time. And how unmistakably do all these investigations prove what we ought to have known and accepted without a moment's hesitation, that the Creator that has made such vast and such minute provisions for supplying every living creature with a constant and copious supply of fresh air, has made it so important for their existence that they cannot live a moment without it, has made the air at night just as pure and wholesome as in the day-time.

We have thus traced the scourge of foul air to our houses, and much of it to our bed-rooms. The next question is, how to get clear of it.

We want to know, however, what poisons the air, so as to know in what part of the room it is to be found.

We will try a very simple experiment, to show you what a deadly poison the breath is,—to the flame of a candle, at any rate.

Here is a simple glass tube, open at both ends—an ordinary lamp chimney—a candle burns freely as you see, and would burn so all night, if it did not burn out. I will now remove the candle, and breathe into the tube through this pipe, and now you see how suddenly the candle is extinguished as I drop it in again.

Fig. 3.

Animals are killed suddenly or after a more prolonged struggle, by the exhaled breath, according to the activity or sluggishness with which the blood circulates—a bird would be killed very soon—some partially torpid animals would live a long time. Man has great endurance—struggles long and hard; but if closely confined, will be poisoned to death in one night, as in the case of those confined in the celebrated Black Hole of Calcutta, and on board of

vessels where they have been confined below decks in time of a storm. Others will struggle on longer, as in the case of the two thousand and twenty-six who died of consumption last year, in Philadelphia.

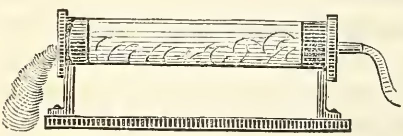
And now let us see in which part of the room this deadly poison of our breath is mostly found.

It is the popular idea, that because the body, and consequently the breath, is warmer than the ordinary temperature of a room, that it rises and accumulates at the ceiling.

Upon this theory most of our buildings have been ventilated whenever any attention whatever has been given to that subject, but that theory is incorrect; consequently, all practice based thereon is also wrong.

This subject of the direction taken by the breath upon leaving the body, has been warmly discussed within a few years. It has been a very difficult matter to prove conclusively and satisfactorily, but I think we have devised some very simple experiments that will prove to you very clearly what we have stated.

I have here a simple glass tube two feet long and one and a half inches interior diameter; one end is closed with a rubber diaphragm,



through which is passed a small rubber tube—the other end is all open. We will rest this about horizontal, and taking a little smoke in the mouth, it will be discharged with the breath into the glass tube; it is first thrown towards the top, but it soon falls, and now see it flowing along the bottom of the tube like water—watch it as it reaches the far end—there, see it fall almost like water.

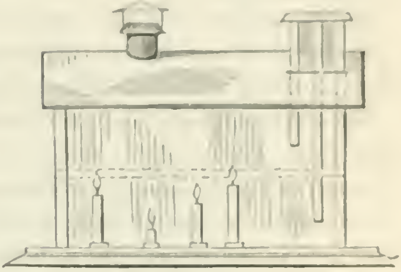
Now, by raising the closed end of the pipe, you see we can pour it all out, and by filling it again and raising the other end, it falls back.

Thus you see that, notwithstanding the extra warmth in the breath, it is heavier than the atmosphere, and falls to the floor of an ordinary room like this, say when the temperature is from 60° to 70°. This is owing to the carbonic acid and moisture contained in it.

I have varied this experiment in a number of ways, by passing it through smaller tubes and discharging it into the air in one or two seconds after leaving the lungs, and by passing it through water of various temperatures, and discharging it into rooms of different temperatures, with the same general results. As the temperature of the air diminishes, the tendency of the discharged breath to rise increases. Much care is required in conducting these experiments,

to avoid as much as possible, the local currents which are always present in a room.

This is a very important fact to be borne in mind; yet notwithstanding this, there are times, under certain circumstances, in which the foul air will be found in excess at the top of the room.



For the further examination of this subject, we have here a little glass-house with glass chimneys and fire-place in the first and second stories.

As the flame of a candle is such a beautiful emblem of human life, we will remove the roof and part of the floor of the second story, and place four candles in our house. They are all of different heights, you see. We will call them a father, mother and two children.

As carbonic acid is that much dreaded poison in our breath, and the heavy portion of it which causes it to fall to the floor, we will make a little by placing a few scraps of common marble in this glass vessel, and pouring over it some sulphuric acid.

It is now forming, and will fall and flow across the floor the same as carbonic acid does when it pours into a basement from the gutters on the street or filthy yards where it is formed, and before it is absorbed or diluted by the current of pure air sweeping over them. It first kills the smallest child, because it is nearest the floor. You remember the excessive infantile mortality in this city in 1865. This is partially owing to their breathing more of this foul air near the floor, and partially owing to the great fear of their mothers and nurses, of letting the little innocents get a breath of fresh air for fear it would give them colic, and consequently they smother them to death.

The other child dies next, and then the mother, and lastly the father.

Thousands are thus poisoned to death by their own breath every year. But did you ever see a physician's certificate that ever gave you any such idea? Why do not the doctors tell the living, in such language as they can understand, what killed their friends, so they may avoid it in their own case, instead of giving it in some Latin terms which I fear many interpret to mean some special dispensation of Divine

Providence instead of the true cause—their utter disregard of the laws their Creator made for the preservation of their health?

Had this family known enough about ventilation to have kept the fire-place open, with a little fire in it now and then, they would not have been thus killed.

Let us see—we will take out the fire-board which has been put in to make the room look a little neater, and with a very small light there to create a draft in the chimney.

We will again light the candles, and pour in the poisonous breath. Ah! there goes the little one—he is hardly high enough to keep out of that deadly current flowing across the floor.

We shall have to let it in a little slower, or we will set him on a platform, as many persons who have carefully studied this subject, consider it judicious to do. Now, by the smoke from this taper, you can see the air is flowing across the floor and up the chimney.

There has been a steady current flowing in long enough to have filled the house, but the lights are all burning brightly, and you thus see the value of an open fire-place for ventilation. Thousands of lives are thus saved, and many more would be if all fire-places were kept open. I have recommended hundreds of fire-boards to be cut up for kindling-wood, as I consider this is the best use that can be made of all fire-boards.

Never stop up a fire-place in winter or summer, where any living being stays night or day. It would be about as absurd to take a piece of elegantly tinted court-plaster and stop up the nose, trusting to the accidental opening and shutting of the mouth for fresh air, because you thought it spoiled the looks of your face so to have two such great ugly-looking holes in it, as it is to stop your fire-place with elegantly tinted paper because you think it looks better.

If you are so fortunate as to have a fire-place in your room, paint it when not in use; put a boquet of fresh flowers in every morning, if you please, or do anything to make it attractive, but never close it.

Now, there are other conditions in which a fire-place or an opening near the floor, will not answer for ventilation. This occurs in rooms where the air is made impure by burning lamps or gas, and where the fresh air entering the room is cooler than the temperature of the room itself.

To illustrate this, we will put the roof on and take the entire floor away, or as it will be a little more convenient, we will represent it by this glass-house, using this shade for that purpose.

This is supported some six inches from the floor, and has no bottom. By lighting another candle and standing it outside, you can judge by comparison, of the foulness of the air inside.

The tallest one is effected first, this time. You see that is a perfectly formed light, but it gives but about half the light the one does on the outside; this is the way with many of us who are obliged to, or rather do, breathe foul air half the time.

We often think, by comparing ourselves with others around us, that we are pretty fair specimens of humanity, while really we do not give more than half the light in the world that we ought to do, and kill ourselves before our work is half done.

You see the two tallest are dead already, and the others will soon follow—there they go. Here is the bottom of the house removed, and yet these candles all went out for want of fresh air.

Therefore, when we see the air is made impure by burning candles or gas lights, owing to its exceeding heat, the foul air is mostly at the top of the room, and especially when the fresh air enters cooler than the air in the room. We will find, however, that in a very few minutes the candles will relight long before the contained air or the glass shade cools down to the temperature of the room.

The products of combustion, like those of respiration, are heavier than the ordinary atmosphere, and consequently fall to the floor very soon if not removed while very hot, by special openings immediately over them in the ceiling; after it has thus fallen, provision must be made for its removal from the level of the floor, in connection with the foul air from the breath.

I hope by these few simple experiments, and the statistics presented here this evening, we have strengthened your previous convictions of the importance of fresh air, because we are well aware that you will find, as you proceed in your investigations of this subject, that it is frequently surrounded with complications, yet the laws governing the circulation of air of different temperatures, are as fixed and immovable as the laws governing the rising and setting of the sun, and with a very little careful investigation, can be easily understood.

And we believe no similar amount of money or thought, will produce a greater amount of satisfaction than the increased health, strength and happiness thus secured.

(To be continued.)

EXPERIMENTS ON THE EVAPORATION OF STEAM-BOILERS USED FOR HEATING PURPOSES.

By James B. Francis, Civil Engineer.

BOILERS IN THE MILLS OF THE NASHUA MANUFACTURING COMPANY, AT NASHUA, N. H.

This experiment was made at the request of Gen. J. C. Palfrey, agent of the Merrimack Manufacturing Company, at Lowell, Mr. Daniel Hussey, the agent of the Nashua Manufacturing Company, furnishing all the facilities required for the purpose.

The boilers were built by the Lowell Machine Shop, and have been in operation since September last. They are plain tubular boilers. Each boiler is twenty feet long and five feet in diameter, with fifty-five wrought iron tubes, 3·25 inches in diameter inside, and about one-eighth of an inch thick. The usual level of the water is about twenty-two inches below the top of the boiler. The grates are placed under the boilers, and are each 4·86 feet long and 5·545 feet wide, having a total area, under both boilers, of 53·9 square feet. The grate-bars are in three lengths, and the spaces between them are about a quarter of an inch in width, and have a total area under both boilers of about 15·19 square feet.

The products of combustion pass, first, under the whole length of the boilers, about one-half of the area of the shells being heating surface; thence returning through the tubes; thence back again through the flues of a heater, placed above and between the two boilers. The heater is about eighteen feet long and forty-three inches in diameter, and has two flues 1·19 feet in diameter.

Fire surface in the shells of the boilers, including that portion of the ends below the water-line	369 square feet.
Fire surface in the tubes	1873 " "
Fire surface in the heater	160 " "
Total area of fire surface	2402 square feet.

The boilers and heater having 44·56 square feet of fire surface to each square foot of grate surface. The boilers and heater are protected from radiation by brick-work and ashes.

The products of combustion from three pairs of boilers pass into a

chimney, about one hundred and ten feet high, having a flue of a uniform section of about nine square feet. In the lower part of this chimney there is a damper, regulated by the pressure of the steam. Each set of boilers has also a separate damper, regulated by hand. During this experiment all the boilers were in operation in the daytime, while the mills were running, and the draught was regulated by the self-acting damper, the hand-damper being generally wide open. In the night, when the boilers being experimented on were alone in operation, the draught was regulated by the hand-damper, the self-acting damper being generally wide open. The dampers all turn on axes, on the principle of the throttle-valve; their positions were noted by means of arcs, graduated in degrees, the indices of both reading 0 when shut, and that in the main chimney reading 65° when wide open, and that in the flue reading 90° when wide open.

The fire surfaces of the boilers and heater were cleaned, and the boilers blown off, within the two days next preceding the commencement of the experiment. This is usually done once a week.

The boilers were supplied with water from a cast iron tank, 4·83 feet in diameter and 5·91 feet high, which was partially filled with water, at intervals, from the town water-pipes, and the water pumped from the tank into the heater, which is kept constantly full and under the same pressure as the steam in the boilers, the water flowing from the heater into the boilers as fast as it is pumped into the former.

The experiment consisted, mainly, in noting the quantity of water pumped from the tank into the heater, during a certain interval of time, and the quantity of coal consumed under the boilers during the same time. In order to ascertain the quantity of water, a glass tube, about six feet long, was attached to a wall near the tank, which was connected at its lower end with the tank by a pipe, so that the water stood at the same level in the tank and pipe; a graduated scale was attached to the glass tube.

In order to gauge the tank, a cask was filled with water to a certain height, and the weight of the water ascertained by platform scales. The tank was then filled by means of this cask, the height of the water in the glass tube being noted after each cask of water was put in, which gave the means of determining, at any time, the weight of water in the tank by an inspection of the height of water in the glass tube.

The pumps being stopped, the tank was filled to a convenient height, which was noted. The pumps were then put in operation, and

the boilers supplied in the usual manner. When the water in the tank was nearly exhausted, the pumps were stopped and the height of the water in the glass tube again noted, which gave the means of ascertaining the quantity of water remaining in the tank, which being deducted from the original contents of the tank, gave the quantity supplied to the boilers for that filling of the tank. This operation was repeated as often as necessary, to keep the boilers supplied with water.

The coal was weighed out at intervals, on the same scales as were used to determine the weight of water in the tank.

The experiment commenced at 3h. 30m. P. M. on Monday, February 11th, 1867, and terminated on the following Saturday, at 3h. 0m. P. M., an interval of 119·5 hours, during which time the fires were maintained with as much uniformity as practicable, two sets of firemen and observers being employed. The temperatures of the air and water were noted; also of the smoke in the flue between the boilers and heater, and in the flue just beyond the heater. Also, the pressure of steam in the boilers, the position of the dampers and the amount of ashes and clinkers.

Care was taken to terminate the experiment when the fire was in the same state as when it commenced—at least, as nearly so as could be ascertained by inspection. The height of the water in each boiler was also noted at the commencement and termination of the experiment, and a correction made for the difference.

Steam-boilers frequently carry over water with the steam, and it is often quite difficult to ascertain how this is, particularly when the quantity carried over is not large. In this case, there was little probability of it, the steam space being larger than usual in boilers used for heating purposes, and the boilers of simple form, very clean and moderately fired. But to get some positive information on this point, I put in a diaphragm at a joint in the horizontal pipe, four inches in diameter, conducting the steam from one of the boilers; the upper part of this diaphragm was cut away, so as to leave an aperture, for the passage of steam, of an area equal to about three-fourths of the area of the pipe, the part not cut away operating as a dam to prevent the free flow of water along the bottom of the pipe. A small cock was put in the bottom of the pipe, on the side of the diaphragm farthest from the boiler, where, from the position of the pipes, water would be likely to lay, if any was carried over from the boilers. This cock was frequently opened during the experiment, but on no occasion was any water found, except the small quantity condensed in the cock.

From all the circumstances, I infer that very little, if any, water passed over except in the form of steam.

The coal used was anthracite, but I was not able to learn, definitely, the kind. It was taken from a shed in which five cargoes, amounting to 1718 tons, were promiscuously deposited last spring. Two of the cargoes were "Locust Mountain" and another "Broad Mountain;" another was called, in the invoice, "White Ash," and another "Bear Valley." From the manner in which the coal was originally deposited in the shed, I infer that the coal used in this experiment was a mixture of these several kinds. The coal was of the size called "broken," containing the usual amount of dust and dirt, which was weighed in and used, and may account, in part at least, for the large proportion of clinkers.

The following are the results of this experiment:

Water evaporated	296,620 pounds.
Mean initial temperature of water in tank	36° Fahr.
Coal consumed under boilers, including ashes and clinkers	34,197 pounds.
Ashes, being everything that fell through the grates	1,963 "
Clinkers	2,138 "
Mean pressure of steam in boilers, above atmosphere	31·4 lbs. per sq. in.
Mean thickness of the fires	7·2 inches.
Mean opening of hand-damper during the night	54°
Mean opening of the self-acting damper during the day	35°
Mean temperature in flue between the westerly boiler and the heater	296° Fahr.
Mean temperature in the flue just after leaving the heater	237° "
Mean temperature by thermometer in boiler room	67° "
Mean temperature out-doors, in shade	35·9° "
Water evaporated from the initial temperature in the tank, by one pound of coal	8·674 pounds.
Equivalent amount of water evaporated from 212° by one pound of coal	10·201 "
Coal burned per square foot of grate per hour	5·39 "
Proportion of ashes and clinkers to the coal	12 per cent.

The ashes contained a considerable proportion of fine coal, partially burned, which was not returned to the fire. The clinkers were not picked over with much care, and a greater quantity of partially burned coal might have been separated and returned to the grate, which would probably have increased the evaporation slightly.

SYNOPSIS OF EXPERIMENTS ON THE EVAPORATION OF SEVERAL BOILERS USED FOR HEATING PURPOSES, MADE UNDER THE SAME DIRECTION AS THE PRECEDING.

February, 1840.—Upright cylindrical boiler in Massachusetts Cotton Mill, No. 1, $31\frac{1}{4}$ inches diameter, 11 feet high. Fire inside, surrounded by a 3-inch water space, which extended nearly to the level of the surface of the water. Over the fire there was a pot, leaving an annular space about three inches wide, for the passage of the products of combustion, which left the boiler by an opening through the water space.

Area of grate surface	3·21	sq. feet.
Area of fire surface	114·25	" "
Fire surface to one square foot of grate surface	35·59	" "
Anthracite coal burned per square foot of grate per hour	12·75	pounds.
Water evaporated from 212° by one pound of coal	7·87	"

February, 1841.—Two upright cylindrical boilers in Massachusetts Cotton Mill, No. 2, similar to the preceding, except that they are one foot higher, and the annular flue extended through the steam space to the top of the boiler.

Area of grate surface in each boiler	3·20	sq. feet.
Area of fire surface in each boiler	126·50	" "
Fire surface to one square foot of grate surface	39·53	" "
Anthracite coal burned per square foot of grate per hour	7·15	pounds.
Water evaporated from 212° by one pound of coal	12·06	"

April, 1851.—Upright cylindrical boiler in Massachusetts Cotton Mill, No. 1, similar to the next preceding, except that the pot contained a flue $9\frac{3}{12}$ feet in height, and $11\frac{1}{2}$ inches in diameter.

Area of grate surface	3·14	sq. feet.
Area of fire surface	154·34	" "
Fire surface to one square foot of grate surface	49·15	" "
Anthracite coal burned per square foot of grate per hour	13·42	pounds.
Water evaporated from 212° by one pound of coal	9·62	"

January, 1851.—Locomotive boiler at the Boott Cotton Mills. The products of combustion passed from the fire-box, which was surrounded by water, through 64 tubes $2\frac{3}{8}$ inches diameter, $13\frac{3}{4}$ feet long, to a smoke-box, also surrounded by water; thence back under the boiler through a heater.

Area of grate surface	16·66	sq. feet.
Area of fire surface, including heater	748·00	" "
Fire surface to one square foot of grate surface	44·90	" "

1st Trial. The surface of the boiler not being protected from radiation.

Anthracite coal burned per square foot of grate per hour ... 6·84 pounds.
Water evaporated from 212° by one pound of coal......... ... 8·88 "

2d Trial. The surface of the boiler being protected from radiation, by felting and brick-work.

Anthracite coal burned per square foot of grate per hour... 7·52 pounds.
Water evaporated from 212° by one pound of coal......... . 9·13 "

3d Trial. Same circumstances as the preceding, except that bituminous coal, from the Vossburgh mines, in Maryland, was used.

Bituminous coal burned per square foot of grate per hour, 7·61 pounds.
Water evaporated from 212° by one pound of coal.......... 10·57 "

February, 1851.—Three horizontal cylindrical boilers at the Boott Cotton Mills, each boiler 20 feet long and 30 inches in diameter, with the two flues 11 inches in diameter.

Area of grate surface.. 38·70 sq. feet.
Area of fire surface...599·00 " "
Fire surface to one foot of grate surface......................... 15·25 " "
Anthracite coal burned per square foot of grate per hour.. 4·44 pounds.
Water evaporated from 212° by one pound of coal........... 7·53 "

Lowell, Mass., Feb. 22, 1867.

DESCRIPTION OF PARHELIUM OBSERVED AT GERMANTOWN.

By C. J. W., Jr., February, 1865.

Mr. Editor: The exhibition of the phenomenon of parhelium, which occurred on Monday, the 4th inst., was of so remarkable a character that the writer has thought it deserving of more than a passing notice, and has therefore prepared the following sketch of its principal features for insertion in your *Journal.*

In the early part of the day mentioned, the sky was unusually clear, the sun brilliant, and the atmosphere, for the season, mild and calm. At 7 o'clock A. M., the thermometer was 30°, with a light southwest breeze. Towards noon, however, the sky became overcast with

a thin haze, and about 1 P. M. the writer's attention was attracted to a point in the heavens, a little to the south of west, by a luminous arc, exhibiting the prismatic colors, which, superficially observed, might have been mistaken for a rainbow. As there was no rain, or even mist sufficient for the formation of a rainbow, the writer was led to suspect the cause of the phenomenon, and upon casting his eyes to the south-eastern heavens, perceived a corresponding arc, which at once convinced him of its true character. Upon further observation, the following particulars were observed: 1 o'clock P. M., thermometer, 46°; barometer, 29·55 ins.; wind, south-west, light; sun's altitude, 33°. Owing to the hour of the day, it is evident that the sun occupied a position in the heavens but little to the west of south, and that he had but just passed his meridian height. At a distance of 40° on either side, with the sun as a centre, and about 15° from the horizon, were the prismatic arcs first observed, having a nucleus in the centre, and gradually diminishing in brightness towards the extremities. The peculiar feature of these arcs was, that they were not concentric with the sun, but, on the contrary, that their convexity was towards him. This peculiarity was observed in a parhelium seen by Hevelius, at Dantzic, in 1661, and is the only instance that the writer is able to find on record.

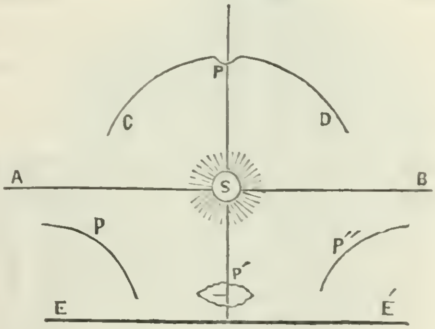
In a perpendicular line, passing through the sun, were to be found two of the most interesting features of the phenomenon witnessed; that between the sun and the zenith, and about 25° from the former, consisted of a concentric, prismatic arc, similar to those already described, except that it was larger and far more brilliant, and that directly in the intersection of the line connecting the sun with the zenith a distinct depression existed, causing the arc to deviate very materially from the line of a circle. The corresponding point below the sun, also at a distance of 25°, was brilliantly illuminated, and by far the most distinctly marked of the parhelia visible, having the appearance of the sun about to burst from behind a cloud. This also faintly exhibited the prismatic colors. The last, and perhaps the most interesting feature observed, was a great circle of white light, horizontally placed, passing directly through the sun's centre. This circle was almost complete, the writer having been able to trace its entire course, with the exception, perhaps, of 20° or 30°, in the eastern heavens. This unusual phenomenon was observed at Rome, by Schreiner, in 1629, connected with a parhelium of four suns, the same number as were observed on the present occasion.

The appearances above described continued with waining brilliancy for about half an hour, and had altogether disappeared in the course of an hour; they were far superior to any display accompanying parhelium ever observed by the writer, who has been so fortunate as to witness it three times, and similar phenomenon of the moon (parselene) once.

In confirmation of the impression that the state of the atmosphere necessary to the production of parhelium is indicative of a change of weather, the writer would merely observe, that by 2 o'clock P. M., on the day in question, the wind had veered to the east, and the sky had shortly afterwards become densely clouded; and that by 5 o'clock rain fell. In explanation of this, it is only necessary to say that the phenomenon of parhelium is ascribed to the existence in the atmosphere of a quantity of frozen spiculæ, floating in a thin fog, the coronæ being formed in the fog and the parhelia in the spiculæ, and that the spiculæ often subsequently fall in the form of cylindrical snow flakes, or melted in the form of rain.

In order that the above description may be more readily understood, I have prepared the annexed diagram, in which are embraced the principal features of the phenomenon.

The parhelia were observed at the four points marked P P P′ P″.



DESCRIPTION OF CUT.

C P D. Arc showing prismatic colors.

A B. Great circle of white light, horizontally placed, passing through the sun's centre.

P and P″. Prismatic arcs.

P and P′. Luminous spots.

E. E′. Horizon.

Educational

(Continued from page 203.)

LECTURES ON ELECTRICITY AND LIGHT.

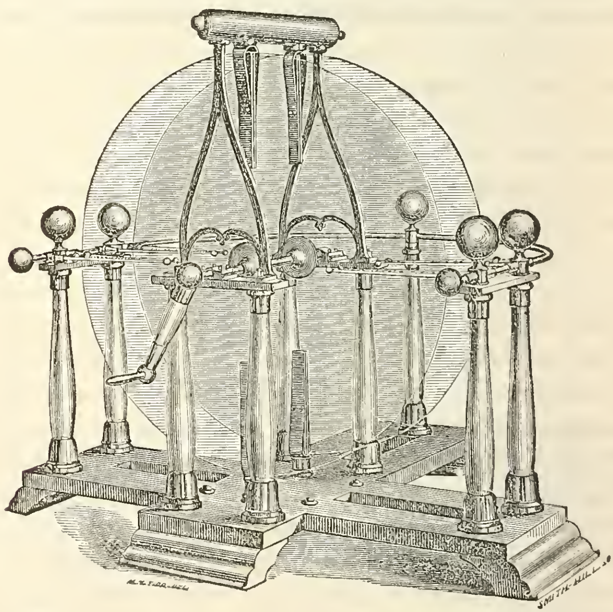
Delivered before the Franklin Institute, by Prof. Henry Morton, Ph.D.

Having now described the general construction of the ordinary electrical machine, and the important points to be regarded in securing its best effect, it may be interesting to notice some remarkable machines which have been manufactured, of the above general type, but distinguished by special features, either of magnitude or constructive detail.

There was built, in 1856, by Mr. E. S. Ritchie, of Boston, for the University of Mississippi, a double plate machine of gigantic proportions and enormous power.

Fig. 7 represents the machine alone, without its prime conductor,

Fig. 7.



which consisted of three cylinders, about one foot in diameter and seven feet long, which were mounted on separate stands.

The plates of this machine are each six feet in diameter, and are excited by eight rubbers of brass, lined with fine wool felt ⅜ of an inch thick, covered in turn with stout India silk, on which the amalgam is spread. Negative electricity can be obtained from the upper system of rubbers, which are connected with the small cylindrical conductor at the top.

This machine cost $3000 without any of its adjuncts, such as the Leyden battery of one hundred jars, having an aggregate surface of about ninety square feet. A single turn of this machine filled a room with an overpowering odor of ozone. No description has ever been published of the results obtained with this instrument, and even its constructor, Mr. Ritchie, (to whose kindness we are indebted for the use of the accompanying cut,) tells me that he cannot furnish information on this subject, as the instrument was sent to its destination immediately on being finished, and that no accounts have been received concerning its operation. This silence, for the last few years, is easily explained by the disturbed state of that section of country, but we may hope before long to have some record of experiments, which would be very interesting, as this is the largest machine of the sort ever constructed.

A few words may be here said as to the special properties of large machines. Increase in the size of the machine, secures an increase in the quantity of electricity developed, and as a secondary result of this, an increase in the spark length. Thus, the machine made by Cuthbertson, in 1755, for Von Marum, with double plates five feet five inches each in diameter, gave sparks of two feet in length.

An ordinary machine, with a plate of thirty inches, on the other hand, is doing very well if it gives sparks of five inches. The reason of this is easy to understand. The large machine can readily supply a large prime conductor, and notwithstanding the increased leakage of this, can accumulate in it a proportionally large amount of electricity. On such a large conductor, the tension may rise higher, before dispersion takes place, into the air, for the reasons already mentioned (page 202), as well as for other causes which will be better understood in connection with the distribution of electricity in conductors, which we shall discuss further on.

In addition to this, all the oppositely excited parts are further apart in the larger machine, and all the terminations are in longer curves, for which case there is, *in proportion*, less loss from leakage. So regular in fact is this increase in spark length in following the

enlargement of the machine, that it was at one time assumed as a fair index in general, of the magnitude and value of the apparatus.

(To be continued.)

(Continued from page 206.)

MAGIC LANTERN AS A MEANS OF DEMONSTRATION.

In place of hydrogen, obtained by any of the means before described, the ordinary illuminating gas may be employed with an equally good effect in all but a few spectrum experiments, to be described in future. To obtain an equal light, however, it is necessary to employ a heavier pressure than is required with hydrogen.

As a practical question, the choice of one or the other material will be determined by local conditions, and especially by the character of the reservoirs used for storing the gases, and after these have been discussed, we will again briefly allude to this matter.

Methods of Storing Gas.

Gas bags of rubber cloth are perhaps most largely employed for the above purpose, and, with certain drawbacks, are of great service. To keep them in good condition, they must be treated with great care, especially after they have once been in use. They should not be rolled or folded, but put away when not in use, on a large shelf where they may lie out flat. They should not be inflated or compressed when rigid from cold, and after use with burning-gas, should be entirely emptied and rinsed with air by means of a bellows, with which they may be partly inflated, and then emptied two or three times in succession. If these precautions are neglected, the life of a gas bag is but short, as is the case with those traveling from place to place, where a few months limit their useful existence. But with care and under favorable conditions, I have had them last for two years, with pretty constant use. Their cost is small—a 30 by 40-inch bag of wedge-shape, and having a capacity of forty to fifty gallons, according to its distension, is sold by R. Levick, 708 Chestnut Street, for $12. This does not include brass connector and stop-cock, which, however, once procured, will last indefinitely. Stop-cocks of hard rubber cost $2 each. To force out the gas from these bags, press-boards and

weights of some sort must be employed. For press-boards, mere strong drawing-boards or pie-boards may be employed, the bags being spread upon the floor, the boards upon them, and the weights so adjusted as to preserve an equilibrium. If two bags are used, this, however, requires a double set of weights, and each large bag demanding two hundred and fifty pounds (when nearly empty), this is an important point. Also with bellows-shaped bags, some means must be employed to prevent sliding. For two bags, it is therefore better to have press-boards made of three pieces, hinged together like the letter N, turned on its side, thus Z; a bag being placed in each angle, the stop-cocks passing through holes cut in the wood at these points. One set of weights then compresses both bags, and the whole being connected and steady, equality of pressure is readily obtained by adjustment in the position of the weights; moving them

Fig. 5.

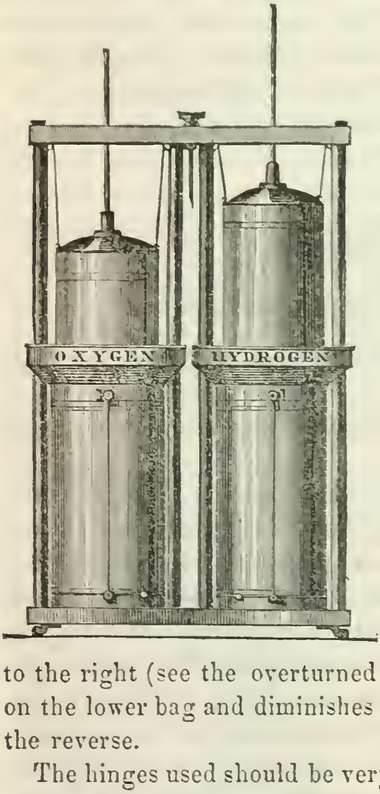
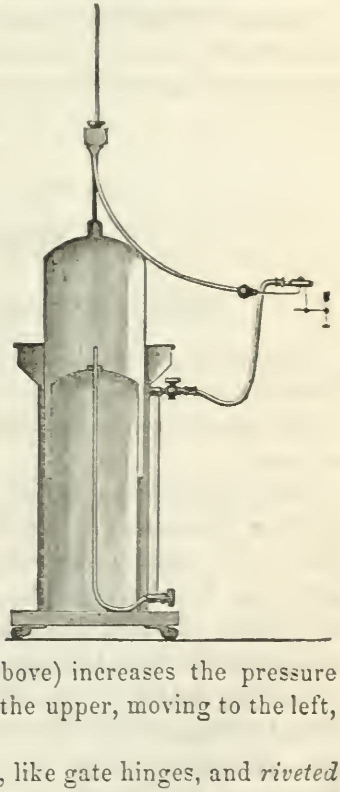


Fig. 6.



to the right (see the overturned letter above) increases the pressure on the lower bag and diminishes it upon the upper, moving to the left, the reverse.

The hinges used should be very strong, like gate hinges, and *riveted* to the wood, then covered by a strip of canvas or oil-cloth, to protect the bags. For weights, twenty-eight pound blocks are the easiest to

handle, but fifty-sixes, buckets of water, coal scuttles, sand-bags and small boys, may all come in play on occasion.

Gas holders, such as are represented in Figs. 5 and 6, may be next mentioned. As fixtures in a laboratory (*i. e.*, only to be moved about the room in which they are used) these are very convenient. They are absolutely tight, so that a supply may be kept on hand for any time, without loss or deterioration, while in the best gas bags a month's storage seriously impairs even oxygen.

No handling of heavy weights is required, as that producing pressure may be left on permanently, and if removed, is relatively small. The pressure during use is absolutely constant, and the whole apparatus practically indestructible. The pattern here shown, is that furnished by Mr. Ritchie, of Boston, who is so widely known by reason of his great improvements in the Induction Coil.

Fig. 5 shows an elevation of a pair of these gas holders mounted on a movable platform which runs on castors, and may thus be easily transferred from one part of a room to another. Fig. 6 shows a section of one holder with the attachment of a blow-pipe.

(To be continued.)

Franklin Institute.

Proceedings of the Stated Monthly Meeting, March 20th, 1867.

The meeting was called to order with the President, Mr. J. Vaughan Merrick, in the chair.

The minutes of the last Stated and Special Meetings were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported that, at their stated meeting, held March 13th inst., donations to the Library were received from the Royal Astronomical Society, the Royal Geographical Society, the Statistical Society, and the Society of Arts, London, England; L'Academie des Sciences, Paris, and la Société Industrielle, Mulhouse, France; the Smithsonian Institution and Chas. Colné, Esq., Washington, D. C.; S. S. Garrigues, Esq., Lansing, and the Board of Water Commissioners, Detroit, Michigan; Managers of the State Lunatic Asylum, Utica, New York; Trustees of the Gas Works and Messrs. Wm. I. Mullen, Frederick Fraley, George Erety and Samuel V. Merrick, Philadelphia.

The various Standing Committees reported their minutes.

The Special Committee on Experiments in Steam Expansion reported progress.

The Special Committee on General Totten's letter, relating to the appointment of a Government Bureau of Mechanical Examination and Experiment, reported as follows:

The Committee appointed to consider the scheme for the establishment of a "Permanent Examining Board for the Army," as proposed in a letter from General Totten, respectfully

REPORT

That they consider that the establishment of such a Board would be beneficial to the interests of the government and the public, but that in the proposed form it would be too expensive, as it involves the time and services of the most useful and accomplished officers, and of a large number of assistants, while there might frequently be times at which there would be no business for the Board to do.

It is also suggested that the National Academy of Sciences, which numbers among its members several officers of the army and navy eminent for their scientific attainments, was established for the expressed purpose, among others, of examining into matters referred to it by any department of the government, and this it is constantly doing by its Committees. Provision is made for the addition of persons not members of the Academy to these Committees, and in this way the services of any officer may be secured. By the law, no compensation can be paid to the members of the Academy; but this does not extend to the added members of the Committees, and any amount of money may be furnished by the government for the expenses of experiment.

For the more elaborate investigation of any invention that has been favorably reported on, a special Board of officers may be convened at any of the arsenals or navy yards, at most of which great facilities exist for experimenting on a large scale.

There has been for some time in existence in the navy department a "Permanent Board or Commission," composed of not more than five members, scientific officers or civilians who happen to be residing in Washington, to whom inventions are referred, and through whose hands an immense number have passed.

A Board of the same kind, composed of officers of *both* services, together with civilians, might be readily established at a mere nominal

cost. It must be borne in mind, that the large proportion of inventions brought forward are entirely worthless, and can be disposed of very quickly, while important ones can be referred to special Boards or Committees.

The Committee, therefore, offer the following resolution:

Resolved, That while in the opinion of the Institute, it is desirable that there should be some way by which inventions, touching either the military or naval services, could be promptly examined and disposed of, the plan proposed by General Totten, of establishing a permanent Board, is too elaborate and expensive, and that it would be better to refer such inventions, first, to the National Academy of Sciences, or to a small permanent Board such as described in the latter part of the report, and then, if necessary, to a special commission of officers and others, ordered for the purpose of more thorough investigation.

Respectfully submitted,

FAIRMAN ROGERS,
WM. J. HORSTMANN,
HENRY G. MORRIS,
J. S. WHITNEY,
J. VAUGHAN MERRICK,
} Committee.

The Special Committee to prepare a memorial to Congress with reference to the establishment of a Uniform Code of Danger Signals reported progress.

The Special Committee appointed to attend the obsequies of Prof. Bache reported that they had fulfilled the duties required of them, and were discharged.

The Committee on an ordinance to provide for the inspection of steam-engines and boilers reported their minutes.

The paper announced for the evening on Ground Batteries, by Mr. A. G. Ballantyne, was then read, and various remarks were made upon the same by Professor Robert E. Rogers, Mr. Coleman Sellers and others.

(The abstract of this paper, and of the accompanying remarks, will be published in the next number of this *Journal*.)

Various communications were then made by different members on various subjects, an abstract of which will be found under the appropriate heads in the editorial department.

The meeting was then, on motion, adjourned.

HENRY MORTON, *Secretary*.

A COMPARISON *of some of the Meteorological Phenomena of* FEBRUARY, 1867, *with those of* FEBRUARY, 1866, *and of the same month for* SIXTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11¼′ W. from Greenwich. By PROF. J. A. KIRKPATRICK, of the Central High School

	February, 1867.	February, 1866.	February, for 16 years.
Thermometer—Highest—degree	55·00	60·00	70·00°
" date	14th.	11, 23 & 24th	23d, '60.
Warmest day—mean	51·83	55·00	59·50
" " date	14th.	24th.	25th, '57.
Lowest—degree	16·50	7·00	—1·00
" date	11th.	10th.	7th '55, 8th '61
Coldest day—mean	24·33	15·00	4·50
" " date	10th.	16th.	6th, '55.
Mean daily oscillation	14·64	13·11	13·46
" " range	6·43	7·42	7·17
Means at 7 A. M.	35·84	30·87	29·79
" 2 P. M.	43·36	39·16	38·74
" 9 P. M.	40·66	35·68	34·04
" for the month	39·95	35·24	34·19
Barometer—Highest—inches	30·970	30·517	30·970
" date	11th.	17th.	11th, '67.
Greatest mean daily pressure	30·862	30·475	30·862
" " " date	11th.	26th.	11th, '67.
Lowest—inches	29·303	29·392	29·065
" date	3d.	14th.	23d, '53.
Least mean daily pressure	29·398	29·529	29·227
" " " date	3d.	1st.	16th, '56.
Mean daily range	0·279	0·245	0·225
Means at 7 A. M	30·087	30·032	29·934
" 2 P. M	30·053	29·964	29·887
" 9 P. M	30·065	29·990	29·918
" for the month	30·068	29·998	29·913
Force of Vapor—Greatest—inches	0·361	0·424	0·549
" date	14th.	24th.	16th, '57.
Least—inches	·049	·048	·013
" date	10th.	16th.	6th, '55.
Means at 7 A. M	·171	·151	·141
" 2 P. M	·174	·170	·159
" 9 P. M	·193	·175	·159
" for the month	·179	·165	·153
Relative Humidity—Greatest—per cent	95·0	95·0	100·0
" date	2d & 20th.	8th.	Often.
Least—per cent.	27·0	30·0	20·0
" date	27th.	1st.	22d, '64.
Means at 7 A. M.	76·8	79·9	78·4
" 2 P. M.	60·2	65·2	63·0
" 9 P. M.	72·7	76·1	75·0
" for the month	69·9	73·7	72·1
Clouds—Number of clear days*	6·	13·	8·3
" cloudy days	22·	15·	19·8
Means of sky covered at 7 A. M	65·3 per ct	45·7 per ct	60·6 per ct
" " " 2 P. M	68·2	58·9	61·2
" " " 9 P. M	61·4	41·1	48·7
" " for the month	64·9	48·6	56·8
Rain and melted snow—Amount—inches	4·820	6·637	3·277
No of days on which rain or snow fell	12·	8·	10·0
Prevailing Winds—Times in 1000	S73°30′W·181	N70°38′W·265	N75°40′W·274

* Sky one-third or less covered at the hours of observation.

A COMPARISON *of some of the Meteorological Phenomena of the* WINTER *of* 1866–67, *with that of* 1865–66, *and of the same Season for* SIXTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11¼′ W. from Greenwich. By PROF. J. A. KIRKPATRICK, of the Central High School.

	Winter, 1866–67.	Winter, 1865–66.	Winter, for 16 years.
Thermometer—Highest—degree	61·00°	63·00	71·00°
" date	Dec. 8.	Dec. 27.	Dec. 2, '59.
Warmest day—mean	57·00	55·33	62·80
" " date	Dec. 8.	Dec. 4.	Dec. 19, '56.
Lowest—degree	6·00	—9·00	—9·00
" date	Dec. 21.	Jan. 8.	Jan. 8, '66.
Coldest day—mean	15·33	2·67	—1·00
" " date	Dec. 21.	Jan. 8.	F.7'55;F.8'61
Mean daily oscillation	12·45	12·29	12·51
" " range	6·10	7·16	6·72
Means at 7 A. M	30·27	31·23	29·76
" 2 P. M	36·61	37·99	37·58
" 9 P. M	33·69	34·05	33·19
" for the Winter	33·52	34·42	33·51
*Barometer—Highest—inches	30·970	30·757	30·970
" date	Feb. 11.	Jan. 8.	Feb. 11, '67.
Greatest mean daily pressure	30·862	30·665	30·862
" " " date	Feb. 11.	Jan. 8.	Feb. 11, '67.
Lowest—inches	29·303	29·392	28·941
" date	Feb. 3.	Feb. 14.	Jan. 23, '53.
Least mean daily pressure	29·398	29·226	29·086
" " " date	Feb. 3.	Dec. 19.	Jan. 23, '53.
Mean daily range	0·240	0·211	0·219
Means at 7 A. M	29·985	29·992	29·947
" 2 P. M	29·948	29·941	29·903
" 9 P. M	29·973	29·978	29·934
" for the year	29·969	29·971	29·928
Force of Vapor—Greatest—inches	0·472	0·509	0·551
" date	Dec. 8.	Dec. 27.	Dec. 2, '59.
Least—inches	·042	·024	·013
" date	Dec.20Jan.30	Jan. 8.	Feb. 6, '55.
Means at 7 A. M	·141	·152	·139
" 2 P. M	·145	·160	·157
" 9 P. M	·153	·1[illegible]	·153
" for the Winter	·146	·158	·150
Relative Humidity—Greatest—per cent	96·0	100·0	100·0
" date	Dec. 16.	Jan. 15.	Often.
Least—per cent	27·0	30·0	20·0
" date	Feb. 27.	Feb. 1.	Feb. 22, '64.
Means at 7 A. M	77·5	79·6	78·5
" 2 P. M	63.7	63·9	65·2
" 9 P. M	72·8	76·6	75·4
" for the Winter	71·3	73·4	73·0
Clouds—Number of clear days†	32·	27·	26·2
" cloudy days	58·	63·	64·0
Means of sky covered at 7 A. M	54·9 per ct	63·4 per ct	62·2 per ct
" " " 2 P. M	61·5	59·1	62·3
" " " 9 P. M	49·0	52·5	48·6
" " " for the year	55·1	58·3	57·7
Rain and melted snow—Amount—inches	10·267	15·199	10·255
No. of days on which rain or snow fell	29·	27·	30·9
Prevailing Winds—Times in 1000	N 78° 9′ W·313	N 77° 4′ W·254	N 66° 33′ W·290

* Barometer—Means for December, for fifteen years.

† Sky one-third or less covered at the hours of observation.

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

Vol. LIII.] MAY, 1867. [No. 5.

Editorial.

THE ELECTRIC LIGHT.

The wants of manufacturers, of photographers, and of those generally who either pursue some business occupation, or work of construction on the large scale, during the dark hours, or who make some special and direct application of light, are energetically demanding an abundant, concentrated, intense, and yet economical, source of light.

When we mention the first three requirements, our minds at once revert to the electric light, as we may perhaps have seen it produced by a powerful galvanic combination. But efficient as this may be, and satisfactory in the points first mentioned, it fails entirely (when developed by galvanic action) to fulfil the last but most important condition of economy.

This subject has been thoroughly investigated in all its relations by Mr. Eben Jayne, of this city, with whose valuable experiments, conducted for many years, we hope before long to make our readers acquainted. The general conclusion reached by this gentleman is, we believe, that where economy is a main point, the electric light produced by galvanic action cannot be profitably employed.

While arriving at this negative result in one point, however, Mr. Jayne has not failed to develop many positive facts and conclusions of great interest and value.

We must then rather look to some other source for the so desirable supply of the electric light-producing force.

There are two directions in which much has been done, and is now doing in this respect. 1st. With reference to the conversion of mechanical into electric force, as in the various magneto-electric machines. 2d. As regards the direct conversion of *heat* (without the interposition of mechanical force or motion of machines) into electric energy; as in the thermo-electric batteries of Becquerel, of Marcus and of Farmer.

As concerns the first of these, we need but mention the name of Wild, to recall to all our readers, those wonderful developments first published in this *Journal* last September, and since fully described in detail in our December number.

We look upon this as the most promising improvement yet made in the production of electric force, and although the Abbé Moigno, in a remark quoted in our last issue, mentions a difficulty which has been encountered in practice—from that heating due to what might almost be called "a friction of forces" which Tyndall has so beautifully exhibited in an experimental manner, by melting an alloy in a copper tube, rotated between the poles of a powerful magnet—yet we do not doubt that this will be easily surmounted.

This machine, as we gather from a statement in our admirably illustrated contemporary, the *Scientific American*, is to be put in operation by a company just organized in New York, and we shall look with great interest towards that quarter, for news of progress.

This is not, however, the last development in the above direction. Something more has been discovered, which, if not yet made effective in a practical form, points very clearly to great practical results in the near future.

We were amused, as no doubt were many of our readers, by a very preposterous account of evidently impossible discoveries made by Mr. Siemens, the well-known inventor of the gas regenerative furnace, which has been going the rounds of the unscientific and would-be-scientific press. We have intentionally forborne to quote and republish any of these statements, because we regarded our Editorial duties as including, among others, a moderate amount of seive-like action, by reason of which we should eliminate from our pages some

of the nonsense which diffuses itself with such admirable facility through our periodical literature, scientific and otherwise. We have now, however, in the *Chemical News*, just received the true version of the story, which, without transcending the bounds of possibility, is wonderful enough to excite our interest and reward investigation. We quote this therefore in full :

"The apparatus used in Mr. Siemen's experiments, consisted of two electro-magnets, coiled with long and thin wires, and between the poles of these electro-magnets an armature, also coiled with long and thin wires, was made to revolve rapidly by means of pulleys.

"When a voltaic battery was connected with the wires of the electro-magnet for a few moments, and afterwards disconnected, the residual or permanent magnetism of the electro-magnets was sufficiently strong to generate a feeble current of electricity in the wire of the revolving armature. The feeble current thus generated, was then transmitted through the coils of its own exciting electro-magnet, instead of the current from the battery, and by the mutual action and reaction of the electro-magnet, and the armature upon each other, the magnetism of the machine could be exalted to such a degree as to require the application of very considerable power to drive the apparatus.

"That this increase of magnetism was attended by an increase of dynamic electricity in the wires surrounding the armature and electro-magnet, was manifest from the brilliancy of the spark at the commutator and the increased deflection of a galvanometer needle placed within the influence of the electro-magnetic circuit ; but the quantity of electricity was not sufficient to ignite wires, and was comparatively small in proportion to the mechanical force expended in producing it.

"The apparatus used by Dr. Wheatstone in his experiments, which was also shown in operation at the meeting, was very similar in construction, and identical in principle, with that of Siemens, though each of these experimentalists appears to have worked out his results independently.

"Instead of the long and thin wire used by Siemens in his machine, Wheatstone employed coils of thicker wires, and the wire on the electro-magnet was of the same diameter, and about eight times the length of that on the armature. The coils of the electro-magnet had consequently about eight times the resistance of the armature circuit. In this arrangement, the wire surrounding the armature being the generating circuit, it follows from a well-known property of the electric circuit, that the amount of dynamic or useful effect which the current is capable of exerting when the resistance of the coils of the electro-magnets is in circuit, is about one-ninth of the total amount which the armament coil is capable of evolving, when the electro-magnet is excited to the same degree by a separate battery or other electro-motor.

"This peculiarity of the machine was made evident by Dr. Wheatstone, in a very striking manner, by means of the following well-devised experiment:—Two branch wires were led off from the extremities of the armature coil, and when the electro-magnet was fully excited, the free ends of the branch wires were bridged across by means of a fine platinum wire about nine inches in length, which wire immediately became white-hot, and as suddenly ceased to be visibly hot until contact with the branch wires had been broken for a short time and afterwards re-established.

"This momentary ignition of the platinum wire appeared to Mr. Wilde to be due to the diversion of the greater portion of the current generated by the armature into the new channel or short circuit established by the platinum wire through the armature coils, before the high degree of magnetism which had been maintained in the electro-magnet by the full current from the armature, had been reduced by the loss of a portion of the current so diverted.

"The results obtained by Siemens and Wheatstone are undoubtedly very interesting from a scientific point of view, but, practically, the exciting of the electro-magnet by the current from the armature used in connection with it, produces results very inferior to what are obtained from similar machines, the electro-magnets of which are excited by a separate source of electricity of small power, as, in the latter case, the full force of the current generated by the armature coil is available for the performance of external work.

"Mr. Wilde having himself, some time ago, made some experiments similar to those of M. Siemens and Dr. Wheatstone, came to the conclusion, that, in the present state of our electrical knowledge, the difficulty of utilizing the current from the armature, after it had passed through the coils of the electro-magnet was insuperable; as it is absolutely necessary that the coils of the electro-magnets of electro-magnetic machines, when excited by intermittent currents, should be of considerable length, in order that they may acquire and retain a charge of electricity or magnetism, as has been shown by Drs. Henry and Faraday in their experiments on the induction of a current upon itself. On the other hand, for the production of powerful electro-dynamic effects, it is necessary that the wire of the armature coil should be comparatively short and thick. Hence the incompatability of the armature and electro-magnetic circuits, when exalted dynamic effects, outside the machine, are required.

"It is not a little interesting to observe, how, in the progress of physical science, the same train of reasoning is often pursued by several individuals having no communication with one another. In the present instance, it would appear that the 'augmentation of the power of a magnet by induction currents produced thereby, and reacting upon the magnet itself,' has also suggested itself to other experimentalists besides M. Siemens and Dr. Wheatstone. In a letter published in the *Engineer* of July 20, 1866, p. 42, the writer (Mr. J. Murray) says:—'The description in recent numbers of the *Engineer*

of Mr. Wilde's admirable improvements in the magneto-electric machine, induces me to point out, if you will permit it through your columns, a variety of the principles embodied in his machine, which is so obvious that it cannot fail to be hit upon, by some inventor before long.'

"It is briefly this:—'Whereas, Mr. Wilde, beginning with an ordinary magneto-electric machine, uses the current obtained from it to charge a powerful electro-magnet, and from this obtains a second and more powerful current, which, used in like manner, produces one still more intense, I, using only a single machine, pass the current obtained from its armatures through wires coiled round the permanent magnets, in such a direction as to intensify their magnetism, which in its turn, reacts upon the armatures and intensifies the current.

"'It is obvious that the amount of mechanical force which can thus be converted into electricity is only limited by the capacity of the iron for magnetism; just as the power of a steam engine is only limited by the capacity of the boiler for absorbing heat."

"Mr. Wilde has also received a letter on the subject of his recent experiments in magnetism from Mr. Moses G. Farmer, of Salem, Mass., United States, dated November 9, 1866, in which he says, that he had obtained an increase of 31 per cent. in the power of a magneto-electric machine, by transmitting the current from the armature, through coils of wire surrounding pieces of soft iron forming the prolonged extremities of the permanent magnets of the machine. Mr. Farmer, in the same letter, adds:—'I have built a small machine in which a current from the thermo-battery excites the electro-magnet of your machine to start it, and after the machine is in action, a branch from the current of the magnets passes through its own electro-magnet, and this supplies the magnetism required. It is not exactly like a person standing in a basket and trying to lift himself—because the electricity proceeds from the conversion of the mechanical energy, which must be continually supplied. Neither can it in any wise be likened to the various schemes for producing perpetual motion; but depends on the principle that the actual energy of the mechanical force, conjointly with the potential energy of the magnet, can develop a greater amount of potential energy than is originally resident in the magnet, or, in other words, it is a method of converting part of the actual energy of the prime mover, into the potential energy of magnetism.'"

The discovery of these facts undoubtedly opens the door to many new and important results.

With regard to the second method of obtaining electricity, that by direct action of heat, much has been done of late years; but the improvements yet made, though securing an immense advance upon previous attainments, have not brought this source of electric power up to the level of practical applicability.

Mr. Farmer, of Boston, mentioned above, has gone the furthest, we believe, in this direction, and with his thermo-electric batteries, somewhat resembling, in shape at least, the cylinders of ordinary stoves, and filled like them with burning coal, produces some sort of continuous electric light; but he has made no publication of his results, and what is above stated is only from report.

As regards the application of such electric lights as we possess, to practical purposes, much is being done. Thus we learn from the Abbé Moigno, that the electric light of the Alliance Company is installed on the yacht of the *Prince Napoleon*, where it will be employed in experiments as to the possibility of thus illuminating a distant coast, fort or vessel. Experiments are also in progress on the the East Railway of France, with a view of lighting depots, and tunnels in course of construction, and, as we noticed in our last issue, one of these lights has been employed in the shops of the North Spanish Railway.

NEW INVENTIONS.

At the last meeting of the Franklin Institute, there were exhibited a number of new inventions and improvements, some of which are of sufficient value to deserve a descriptive notice.

An improvement in surveying instruments, of great practical value was exhibited by Mr. F. Seelhorst, of this city. This improvement consists in an arrangement, by which the draw-tube of a small telescope may be adjusted in a manner analogous to that employed in moving in or out the point of a pencil case, and without the use of the rack and pinion commonly employed. The advantages claimed are as follows: 1st. the tube being always covered will be less liable to corrosion and sticking. 2d. The instrument relieved of its pinion head is less liable to catch when carried through underbrush, &c. 3d. The apparatus is stronger than the rack and pinion, because bearing on five screw threads in place of a single tooth.

A car break for the entire train, under the control of the engine driver, by S. McCambridge. In this arrangement a barrel is, by the action of a lever, thrown in gear with the driving axle of the locomotive, and winds up a chain which is practically continuous throughout the train. Under each car this chain passes over a fixed

pulley, and is returned over a movable one at the end of a bell-crank lever, which actuates the system of breaks for that car. By this means a given strain brought upon the chain, repeats itself equally on each car, thus giving an immense aggregate effect without excessive tension at any point.

The advantages of such a system are many and obvious, among which especially may be considered this: That the entire control of the train being in the hands of the engineer, he may *instantly* "break up" his train in a case of emergency without waiting for any secondary action of others; and, it being easy for him, at any moment, to relieve the brakes, after putting them on, he will be the more likely to use this as a precautionary measure in cases of *threatened* danger, where he might otherwise prefer a risk to the necessity of an entire stoppage.

An improvement in valves, by Thomas Shaw. This consists in fitting a slightly conical or tapering valve to a cylindrical seat, by cutting a fine screw thread upon each, the same thread being continued upon the stem of the valve, and forcing it into its seat. By this means a perfectly tight valve is produced with little labor, and nicety of adjustment. The principle involved is precisely that applied in all hydraulic fitting, where tapering pipes are screwed into cylindrical holes, and make perfectly tight joints, but the present application of it is ingenious and effective.

A gauge-cock whistle was also exhibited by Mr. Shaw, which is intended to be attached to any ordinary gauge-cock, and will, when the cock is open, produce a whistle-sound if steam escapes, a bird-like note with foam, and no sound with water. By this means, not only is the engine-tender enabled more certainly to know the state of the water in his boiler, but the whole establishment are likewise notified of the same fact whenever he opens the try-cocks.

ENGINEERING ITEMS.

Making a new river and tunnelling an old one.—We have received the following very interesting particulars from Prof. De Volson Wood, of the University of Michigan, who moreover promises us more of the same sort:

"About two months since, I was at Joliet, Illinois, and saw them

working on the Michigan and Illinois Canal. They are deepening it, so that canal boats can float out of Chicago river into the canal, thus avoiding a lock at Chicago, and also causing a current in Chicago river. To do this, they excavate through solid limestone, about ten feet deep, for about eight miles. The expense is paid by the city of Chicago. The primary object is to improve the Chicago river, a work much needed, and one which will undoubtedly be secured by the plan adopted. It will take two years more to cut through the rock.

"I was there but a short time, on a stormy day, or I would have learned more of it. I learned, incidentally, that it would cost Chicago about $1,500,000, but the information was not official.

"I have also learned, but not officially, that the Legislature of Illinois has voted $5,000,000 to make a ship canal from Chicago river to, and down the Illinois river.

"The city of Chicago is tunnelling Chicago river where it is crossed by Washington street. This will be a great relief to the business community. The business on the river is so great that it keeps the draw bridges on the move almost constantly in the summer time. Doubtless the river will be tunnelled in several places in a few years."

Pennsylvania Steel Company's Works, at Baldwin, near Harrisburg. We were present last Wednesday at the visit of inspection made by the stockholders of the above company to their now nearly finished works for the manufacture of Bessemer steel. Within the narrow limits now at our disposal, it would be quite impossible to make any full description of these works, but, at a future occasion, we hope to furnish a full account. During the visit above named the various machinery was put through its motions. The huge converters turned over with the combined deliberation and ponderous grace of learned elephants, standing on their heads; the hydraulic lifts glided up and down, the blasts from the blowing engines, roared like a whole menagerie of wild beasts, the various pumps pumped as became them, and everything else was in most satisfactory order.

Among the visitors were the following: S. M. Felton, President of the Steel Company, George A. Parker, C.E., Isaac Hinckley, Henry G. Morris, Edward Y. Townsend, Joseph B. Townsend, John Clayton, John Brown, Percival Roberts, Dr. Spooner, Edward Miller, C.E., Major Henry McAllister, Jr., Ellis Yarnall, Robert H. Lamborn, Wm. Sellers, Wm. B. Bement, Chas. Potts, George G. Lobdell, Edward Hoopes, Dr. Le Conté, Henry R. Worthington and D. A. Hines, of New York, Hugh E. Steele, Messrs. Tatem Bros., Dr. Huston, Wm. Colder, W. Q. Hickok, Mayor of Harrisburg, Charles Hartshorne, Mr. Dimpfel, Thomas Arnold, Charles S. Hinchman, Henry Gilbert, Esq., Aaron Bombaugh, G. Dawson Coleman and others.

Civil and Mechanical Engineering.

(Continued from page 258.)

THE NEW YORK "CENTRAL PARK."

By William H. Grant, Superintending Engineer.

CHAPTER II.

PRELIMINARY AND FOUNDATION WORK IN GENERAL CONSTRUCTION.

Preliminary to the construction of the Park roads a thorough survey of the grounds was necessary, and a careful location of the roads as to lines of direction, curves, grades, etc.

The proposed position of the roads as indicated by a general outline plan was the first point for consideration, as it was necessary to determine, by a careful investigation of the ground, how far it was practicable, with due economy, to conform to such a position. This involved the mapping out of the ground, leveling and making cross-sections and computations of the quantities of cuttings and fillings. More than usual care and labor were required in this work, in consequence of the general rugged character of the ground, the prevalence of rock above the surface and hidden at various depths below the surface, and the considerably more than usual breadth of ground occupied by the roads.

The problem was frequently complicated by other circumstances, such as the crossings of bridle roads, traffic (or "transverse") roads and walks, which were to be passed by bridges either over or under the proposed line of road.

Comparative lines and modifications were necessarily considered, surveyed, plotted out and estimated. When this was done and the best compromise practicable made in the selection of the position of the roads, it was next necessary, where surplus material resulted from the excavations in grading, to find a place where such material could be turned to account and utilized in some other portion of the general work of improvement. In like manner, where a deficiency of material resulted from the excavations to fill the depressions, the site had to be sought on adjacent grounds, whence such deficiency could be made up or "borrowed," and at the same time develop if possible, or at least not detract from, the natural features of the ground selected.

The desideratum was, of course, as in all cases of roads, railroads, canals and similar earthworks, to equalize cuttings and fillings. This process was perfected by modifications and re-adjustments of the grades from time to time, as found practicable after the general location was made, and also by slightly swaying the line of the road laterally, one way or the other, along steep sidehill ground, so that the portions of earth and rock lying above the grades, including the necessary side slopes, would, when excavated and removed, just fill up the intervening hollows lying below the grade-line.

Where there are no restrictions as to the acclivity of the grades of a road and the shortness of curves to be adopted, or as to the position laterally that the road is to occupy, this problem is greatly simplified and admits of a comparatively easy solution. But in the case of the Park roads, it had been decided after a general study of the adaptation of the ground, to limit the maximum grades of the roads to one foot rise in a distance of twenty feet, and to make the curves large and sweeping, so as to admit of the easy turning of vehicles at brisk rates of driving, and of seeing a safe distance ahead; the position of the roads, laterally, was also restricted in most cases, to quite a moderate breadth of ground. Hence it will readily be understood, especially by engineers, that a judicious location of the roads with reference to proper economical considerations, was no light task.

GRADING.

The location of a section of road having been made, the ground was staked out, and the depths of cuttings and fillings marked &c., and the work of excavating, grading and preparing the road-bed for the reception of the road material or superstructure, was then proceeded with. Care was taken in making the deeper fillings, to compact the materials so as to prevent subsequent settling and derangement of the work when the road was finished. All surface-soil, muck and vegetable or perishable matter were removed from the surface in advance of the filling; wet spongy ground was also excavated a proper depth to make room for better material. If surplus stones were afforded by the excavations beyond what were wanted for the road materials, or if the stones were of unsuitable quality for other work, they were deposited in such places and in such positions in the fillings, as were best calculated to facilitate the drainage and give firmness to the road-bed. When large stones and masses

of blasted rock were used in the fillings, care was taken to fill the interstices between them with smaller stones and earth.

The filling was carried on in this way in horizontal layers, until it reached its full height, advantage being obtained as far as practicable during the operation, of the travel of teams and carts over the successive layers, to aid in compacting the material. The filling was evenly shaped at the required height or "sub-grade," a crowning form being given to it transversely of the roadway, corresponding with the intended crown of the surface of the road when finished. The best material was selected from the excavations, for the last or surfacing layer, such as gravel, gravelly or sandy loam, or gravelly clay, as the case might be, and this, after the proper shaping, was firmly and uniformly rolled by heavy cast iron rollers drawn by two horses. Any inequalities or depressions occurring during the rolling, were filled up with fresh material, and the surface kept true to the sub-grade line longitudinally, and to the curved or crowning form transversely. The excavations were sunk generally to the same sub-grade line that the fillings were raised to; if in earth that was not deemed suitable for the road-bed, they were sunk somewhat deeper, and the additional depth was refilled with better material, as before stated. In rock excavations, the rough irregular depressions at the sub-grade depth of the road that were caused by blasting, were filled with small stones and chips, in such a way as to keep the drainage free from the middle of the roadway to the side drains, and as far as practicable, outlets were given to all the deeper cavities of the rock, to prevent water from standing in them.

The road-bed was crowned, adjusted and rolled, after the drainage was perfected, in the same manner in the excavations as on the fillings.

Generally, before the completion of the surfacing process of the road-bed, the necessary trenches were dug for the "surface" and "sub-drainage," and for the water-pipes that were laid alongside the roads, the drains and pipes laid down and the trenches refilled.

DRAINAGE.

After a firm foundation has been secured to build upon, the next important step in good road-making, is drainage. Without a firm foundation no art can achieve a successful superstructure, and without thorough drainage no superstructure, however well founded and otherwise skilfully built, will long resist the severe effects of our

climate. Frost is a most destructive agent to roads and walks. It can only be resisted by depriving it of the means by which it acts—wet and moisture. Water retained in the soil or in the materials composing a road, soon produces deteriorating effects. The foundation is liable to settle unequally, displacing and deranging the materials above, and the surface of the road will wear away more rapidly by attrition, when saturated, producing alternately mud and dust. When the water is acted upon by frost, it will loosen and heave up the best road, and undo in a short time all that the appliances of art, in the use, disposition and manipulation of the best materials, have accomplished. Therefore it is held, that upon the thoroughness of the manner in which the drainage of a road is performed, and its successful operation, will depend the permanence of the work.

Road drainage is of two kinds, sub-drainage, or under-drainage, and surface-drainage. Sub-drainage applies to the disposal of water that finds its way to the road-bed below the road materials, and into the ground forming the road-bed and immediately adjacent.

Surface-drainage applies to the rain-fall and water from melting snows and other sources, received on the surface of the road and side slopes, and to the mode of conducting it away before it enters the ground or accumulates in too great a volume.

1st. *Sub-drainage.*—Where the roads were laid on fillings or "made ground," the nature of the materials was generally such as not to require special sub-drainage; where they were laid on or very near the natural surface of the ground, and on excavated ground, which constituted the larger portion, sub-drainage was essential.

In rock excavations the mode of drainage of the road-bed has been in part indicated. In both rock and earth excavations, side trenches were excavated, following nearly the lines of the road gutters, for the reception of drain-pipes for both sub-drainage and surface-drainage, and also for the water distribution pipes of the Park. The latter pipes occupy but one side of the road, branch pipes being laid from them where necessary across the road, to supply hydrants on the opposite side. In rock excavations, to save expense, the water pipes, surface-drainage and sub-drainage pipes on one side of the road, were all laid in one trench, and on the opposite side of the road the sub-drainage and surface-drainage pipes were also laid in a single trench.

In earth excavations and in crossing fillings or made ground, the

water pipes are laid in a separate trench from the other pipes. At intervals of about three hundred feet along the roads, "silt basins" are constructed (as will be hereafter described) on each side of the road, into which the sub-drainage pipes discharge, and the water flowing out of the basins is conducted through a short branch pipe, into the larger surface-drainage pipes. The sub-drainage pipes, in consequence of their discharging at these short intervals into the silt basins, are not required to be large, and are composed of common drain tiles of 1½ to 4 inches bore. They are laid at a depth of three to three and a half feet below the surface, with an inclination of, generally, not less than one foot in one hundred feet of distance. The manner of laying them is the same as that adopted in the general sub-drainage or agricultural drainage system of the Park, which is as follows: The separate pieces of pipe are carefully and truly placed on the bottom of the trench, with their ends in contact; a "collar"—which is a short section of a larger sized pipe—being slipped over the joint, or a "saddle"—which corresponds with about the half of a collar divided longitudinally—is laid over the joint to prevent dirt from entering or being drawn in by water. The collar is preferable to the saddle, as it is the more effectual safeguard against the joints of the pipe or the pipe itself, being choked with earth. The drainage water gathering in the bottom of the trench, finds its way freely, in all ordinary cases, through the slight annular space (the collar fitting easily but not too loosely) between the pipes and collar, and through the inclosed joint into the pipe. The roughness and inequalities of the ends of pipes, although in contact, afford sufficient openings for the water to percolate through, and the frequency of the joints (about twelve inches apart) gives room for the admission of water in no great length of pipe, equal to the capacity of the pipe to carry safely. The covering of the pipe with earth is done with care, a light layer of selected material, free from stones and lumps, is first packed around and over it so as to cause no derangement of joints, and the balance of the trench is then refilled and thoroughly rammed, to prevent as far as possible, any future yielding or sinking away of the earth.

The pipes in the side trenches of the road extend in this manner from one silt basin to another, starting a few feet in advance on the down-stream side of one basin, and extending to and entering the next one in the descending series. Lateral or branch drains are laid from these drains, running obliquely in the ascending direction, to

the middle of the roadway, and are placed at greater or less distances apart, according to the circumstances of the ground. These lateral drains are composed of smaller tiles than the side drains; sometimes instead of tiles, cobble or small quarry stones are used, and in such cases a shallower trench is dug than for tiles, the trench being from fifteen to eighteen inches deep below the sub-grade of the road, and of a width about equal to the depth. The trench is filled with stone or with stone and coarse gravel, to the surface, and a communication is made at the lower end of the drain with the side or main drain running parallel with the road, by a short piece of pipe, having one end fitted into the side drain and the other end extending into and surrounded by the stone or gravel. Drains of this kind are sometimes called "mitre drains." Sometimes, where more than ordinary precautions are necessary for draining the road-bed, the tiles for the lateral drains are covered with coarse gravel or rubble stones in place of earth, and the trench is partially or entirely filled with the same material. The main side-drains are also occasionally treated in the same manner.

This method of sub-drainage was applied more particularly, in the detail in which it is here described, to the wider roads of the Park that were earliest constructed, the widths being from forty to sixty feet. For the roads of less width later constructed, the process was somewhat modified. The side-drains, by being brought closer together (by the less width of the roads), rendered, on most ground, the lateral or mitre drains of the road-bed unnecessary. Considerable portions of the narrower roads (thirty-three feet wide) were laid on "made ground" that was composed largely of blasted rock and stone filling, and therefore needed no additional sub-drainage of any kind.

2d. *Surface-Drainage.*—The surface or superficial drainage of roads is quite different in character from the sub-drainage, but is not the less important. Its object is in part, to relieve or assist the sub-drainage by disposing of water that would otherwise, to more or less extent, filter into and saturate the ground, but mainly, its purpose is to guard against the sudden gathering of water in large volume, and the gullying of the ground along the road, or sweeping away or abrading the road material. To illustrate the necessity of such a provision, it is only necessary to recur to some well-remembered instance—within the experience of most persons—of a country road where the effects of showers of rain have been seen in the deep and dangerous gullies formed by accumulations of water following a long

distance in the line of what was once, perhaps, intended for gutters, without any escape or outlet.

The first element to be considered in a proposed system of surface-drainage, is the amount of rain-fall to be provided for, and the next step is to devise the most practical and efficient means, with a due regard to economy, by which to attain the desired result. The mean annual amount of rain-fall, including melted snow, as furnished by meteorological tables, is not a safe guide, the extremes only (that are not generally recorded) of rain-fall in the shortest spaces of time, furnish such data as is necessary for the object. This, however, if accurately ascertained, can only be taken approximately, and must be very much modified by a variety of circumstances. It would not be practicable to give to any artificial system of drainage, such a capacity as would meet emergencies that arise at widely occurring and uncertain intervals of time, as the great expense of such a system would, in all probability, surpass the amount of injury that might be done through the inadequacy, at such a juncture, of a modified plan. We do not find in the economy of nature, works of an hydraulic character upon so extended a scale as this. Rivers sometimes overflow their appointed channels, and flood plains and valleys; and rivulets that course down mountain slopes for years together in capacious and well-worn beds, are occasionally swollen in so unusual a manner as to break over and abrade away their strong and rocky barriers.

Where Providence does not provide for extreme elemental contingencies, it would scarcely be wise for man to attempt to do so.

A practical mean has to be found somewhere between the occasional or ordinary, and the remote or contingent extremes of rain-fall before settling upon the practical capacity of drainage works. This point received a good deal of attention in connection with the roads and the general subject of the surface-drainage of the Park. All available information and examples were consulted, but no special rule could be deduced, past experience and practice having settled at most, only general principles, leaving the formulæ applicable to any particular case or locality, to be worked out according to individual judgment and the peculiar attending circumstances. The nearest approach that has been made to definite rules and unanimity of opinion, is in the drainage of cities; but here, even, differences exist that are not easily reconcilable. Besides, the circumstances are so different in the two cases of city drainage and open land

drainage, that a rule, however clearly established in the one case, would not safely apply in the other.

The question was settled as regarded the Park roads, by deciding upon such a provision for the drainage as would safely dispose of an amount of surface-water equal to a rain-fall of two inches in depth in the space of one hour. It is rare that such an amount of rain falls in this part of the country. No recorded instances have been met with of rain to that extent in the vicinity of the city of New York. The only instance that is known to be reliable, occurred on a part of the Central Park grounds on the 13th day of July, 1859. The quantity of water that fell at that time in the space of half an hour (within a fraction), was two inches, as ascertained by a rain-gauge that was kept by the engineer department. It occurred during a heavy thunder shower, the violence of which lasted but little over the half hour, and which was evidently very local in extent. The amount of water was very unusual, being just double what it had previously been decided to provide for in the drainage system, and it would have been alarming, had it not been known to be unusual and exceptional.

The portion of the Park grounds upon which the most of the shower appeared to fall, had not, at that time, been much broken up or disturbed by the progress of the various works of improvement, and but little damage was done by the water.

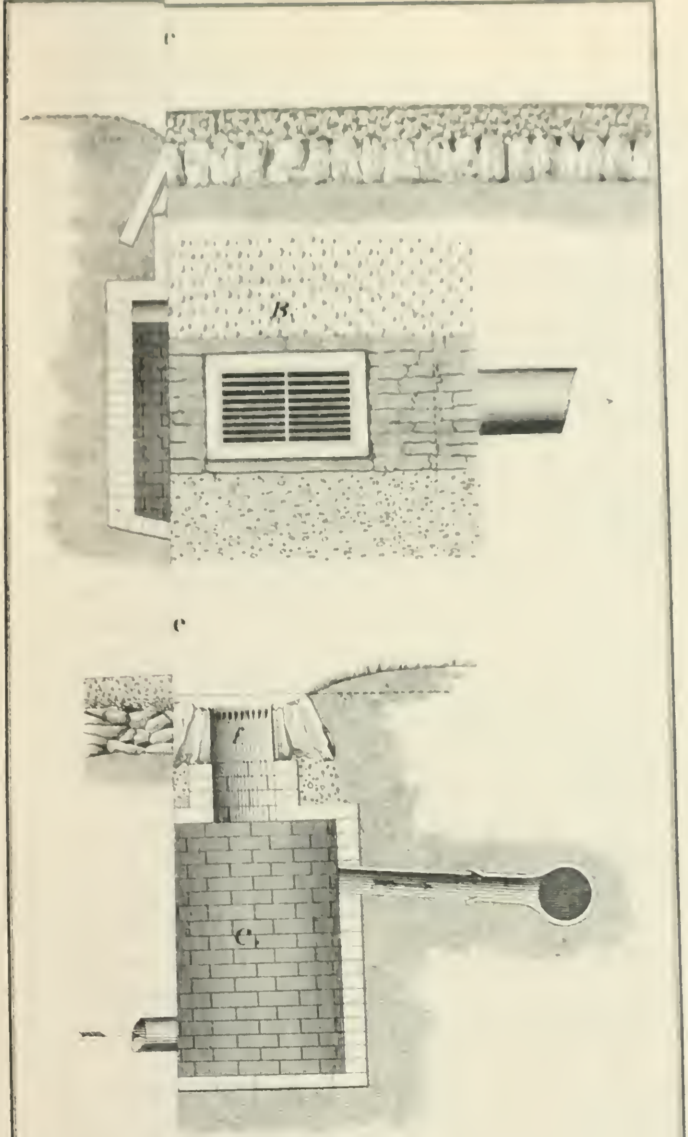
No similar rain storm has occurred on the Park since that time, nor has a quantity of rain since fallen, it is believed, at any one time, equal to two inches depth in one hour.*

Had the drainage works of the Park been fully completed, together with the roads and other works of improvement when this storm occurred, it is not imagined that very material damage would have been done. Some injury would doubtless have been sustained by the roads, by the overflowing of gutters and washing off of the surface materials, and temporary ponds might have been formed in depressed portions of the grounds, but nothing more serious would have been likely to have occurred by a shower that was *so limited in its range and duration.*

(To be continued.)

---

* The Croton Aqueduct Department report "an extraordinary rain-fall in the city of New York, in October last, of upwards of four inches in about five hours."

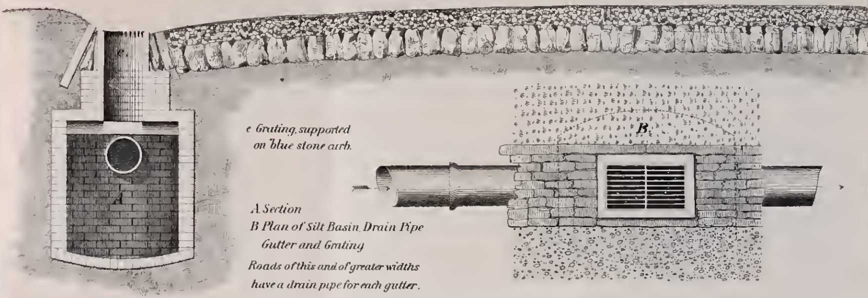


on . D.Plan of Silt Basin,
n Pipe Gutter and Grating.

W.B.Swan del.

Half Section of Telford Road 45 feet wide

Scale $\frac{1}{36}$



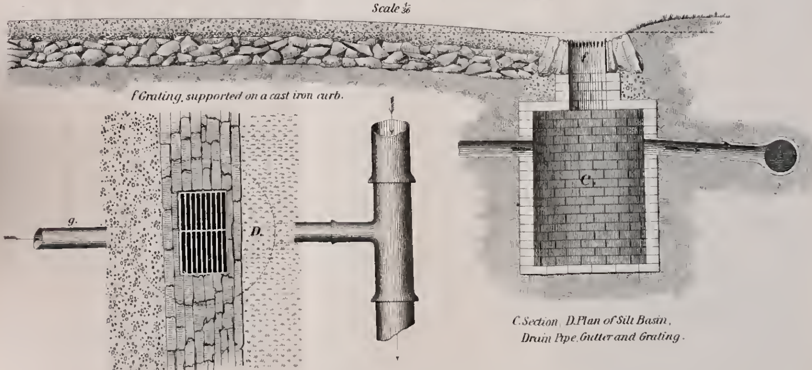
e Grating, supported on blue stone curb.

A. Section
B. Plan of Silt Basin, Drain Pipe Gutter and Grating

Roads of this and of greater widths have a drain pipe for each gutter.

Half Section of Gravel Road 33 feet wide

Scale $\frac{1}{36}$



f Grating, supported on a cast iron curb.

C. Section, D. Plan of Silt Basin, Drain Pipe, Gutter and Grating.

g. Drain pipe from Silt basin on opposite side of road. This arrangement applies to the narrower roads having but one longitudinal or main drain pipe.

W. B. Swan, del.

PERMANENT WAYS.

The following paper, descriptive of some recently tried plans for dispensing with wooden sleepers on railroads, and substituting iron for all the parts of the permanent way, and the discussion on the material used in construction, which succeeded its reading at the rooms of the Society of Arts, in London, will be found particularly interesting by the American Civil Engineer at this period.

The recent prosperity of the various corporations controlling our most important lines, has placed their exchequer in such a condition that many structures of a costly and solid character, are being planned and built.

The desire to reduce operating costs, even at some expense to the interest account, leads every inquirer to consider favorably plans for increasing the perfection or durability of the structure under his charge.

No part of our American railroads is perhaps open to more improvement than the permanent way. Within a decade, however, we can mark a great advance from the narrow strap-rail laid on wooden stringers, such as was in use on the Virginia Central and other roads. This was succeeded in many localities by the light T rail with its thin rattling chair, placed on a single tie, which was in turn followed by the heavier sixty-four, sixty-seven and eighty-five pound rail, with fish joints, braced with wood and placed on two ties, that is still largely in use on our best lines. This system is in its turn giving way to the magnificent superstructure such as the Lehigh Navigation Company is about to lay down, and the Pennsylvania Railroad Company is engaged in laying—composed entirely of heavy Bessemer steel rails, carefully jointed with well-secured wrought bars.

The direction in which our contemporaries in Germany and England are progressing, may be partly gathered from the following paper. The experience of the German roads in this direction, is all the more valuable because they use a section of rail not very different from that chiefly adopted here,—the flat-footed or American rail. The facts set forth may also be useful because they describe a superstructure entirely composed of iron, which in some modified form will in a future period be found most expedient for use on the vast woodless plains of the west and south-west.

From the London Journal of the Society of Arts, No. 740.

THE IRON PERMANENT WAY IN USE ON GERMAN RAILWAYS.

By T. A. Rochussen, C.E.

The system of making railways, by levelling a layer of ballast and forming an upper-structure of wooden sleepers, cast-iron chairs, topped with a wrought-iron rail, and held together by a wooden key, has, for a great number of years, appeared to German engineers to be unworthy an age in which the manufacture of good iron, and its composition into an efficient bearing system, are far better understood than thirty years ago, when the importance of railways as the principal arteries of our social and commercial intercourse was only just foreshadowed.

While locomotives and rolling-stock had, in their construction and performance, progressively represented the advance of practical science, and embodied the genius of the designer, the care of the builder, and the aptitude of the worker in metal, to provide for all the requirements of traffic, it was felt in Germany as well as elsewhere, that the time had arrived to apply the same intelligence to permanent way; and that it had become necessary, as much as possible, to reduce the variety of material, and to avoid that most liable to perish, like wooden sleepers or cast-iron chairs, alike destructive to the wood below and the wrought-iron above; and finally, to get rid of the crude contrivance of fixing rails by means of wooden keys. For this reason, the double-headed rail, copied from English precedent, has enjoyed little favor in Germany, and where adopted, is gradually superseded by the more general practice of flat-bottomed rails, with or without bed-plates on the sleepers.

The failure of Barlow's permament way (perhaps a great deal owing to the use of inferior material) unfortunately discouraged railway directors from pursuing or sanctioning experiments in the right direction, and jeopardizing dividends. While, therefore, different scientific papers published a number of schemes for the construction of iron permanent way, some patented, others given away *pro bono publico*, and all of them eagerly discussed at the meetings of practical engineers, the first step to realize a project was only made at the end of the year 1863, by putting in hand the different systems herewith illustrated, some of which came into actual use in the beginning of 1864, others in 1865.

The theory which guided these constructions, may be summed up as follows:

The nearest approach to perfection in a permanent way, is to present to a moving load a sufficient, an unmoveable, continuous,. and even resistance, as the only means of obviating the oscillation and thumping of fast trains.

Although the weight and height of the rails have been steadily increased, in order to spread the rigidity of the line over a large number of cross-sleepers, there remains in practice an unavoidable deflection of rail between the points of support.

The bending down of the sleeper-end, taking place during the passage of the engine and the oscillation of the carriages or trucks, especially with old or soft wooden sleepers, sufficiently shows that the pressing load is not spread equally over the whole length of the sleepers, and is not evenly supported for the entire length of the wheel base, but that the chair, or point of support, receives a succession of blows, with the whole weight of the load resting on the axle.

If, therefore, we could devise a longitudinal way, possessing sufficient rigidity to transmit the pressure of the load over a large bearing surface, we should avoid the wave-like motion occasioned by the cross-sleepers.

This resistance to pressure can be obtained in a simple ratio, by increasing the flat base resting on the ballast, or, more economically, by increasing the height of the rail, since the power to support grows in the square ratio of the height.

The boldest and simplest plan of iron permanent way under consideration, was that advised by Mr. Hartwich, engineer of the Rhenish Railway, and laid down on the right bank of the Rhine, between Coblentz and Oberlahnstein on a perfect level, and also between Mechernich and Enskirchen, the latter an incline of 1 in 70, and on a curve of 800 yards radius.

The ballast, always an object of especial solicitude with Prussian engineers, is of broken flint, and laid in a channel three feet broad at the top, shelving down to one foot, and eighteen inches deep. The rails shown in section A (see Fig. 1) eleven inches high, weighing 115 lbs. per yard, with a flat bottom of four inches. are placed immediately in contact with the ballast, and sleepers or bed-plates are dispensed with. The space between the rails up to the middle of the head, and also the clear way outside the rails, are filled with fine gravel, tightly rammed in.

The rails are fished vertically and horizontally, as the rail of section B, nine inches high, which has since been ordered to the extent of fifteen miles, on the line between Kempen and Kaltenkirchen, and its adoption is likely to extend with the growth of Rhenish railways to the exclusion of the eleven-inch rails, which were found unnecessarily heavy and expensive. These rails are nine inches high, with a flat bottom five inches wide, weighing 85 lbs. per yard; the head, down to one inch of the web, is formed of steel, the web of fine grain, and the bottom of fibrous iron.

The vertical fish-plates, eighteen inches long, have two rows of fish-bolts for each rail-end, and to increase their stiffness have a longitudinal rib, resting against the web of the rail. The horizontal fish-plates, also eighteen inches long, are eight inches wide, and their connection with the rail is established by means of a cramp-plate, held between the nuts of the fish-bolt, and bearing upon the base of the rail. The use of this cramp is principally to allow a greater width of fish-plate, and to protect it against buckling up by the pressure of the rail. The rails are held to gauge by one-inch round bars, placed three

feet apart, the ends of which are provided with a screw-thread, nut, and washer, at each side of the web, so as to allow an easy adjustment of widening or narrowing the rail distance to the proper gauge. Alternately, the cross, or gauge bars, are put either three inches from the top of the head or three inches from the bottom of the rail.

The whole weight of the system is 145 tons per mile per single line of way; the contract price all round being £13 15*s*. per ton; or, exclusive of ballast and laying down, £1985 per mile.

The engineer reports: "Since June, 1865, the double line from Coblenz to Oberlahnstein and the Mechernich line have been worked with tender-engines weighing 37½ tons; no alteration has taken place in the level of the way, and the rails have nowhere worked into the ballast. The gauge has not in any instance been disturbed, the repairs of packing have been very trifling, and far less than on the line with cross-sleepers. The whole length forms a continuous, unmovable railway; and although there is a little bending at the fish-joints, this inconvenience is imperceptible compared with the advantages of the whole system. The filling of the rail space with gravel provided a more efficient security against sliding than the dogs and bolts in the wooden sleepers. The motion on the rail is perfectly free from oscillation aud thumping; the noise of the passing train has a deep rolling sound, and although some passengers, who are acquainted with the peculiarity of the construction, pretend that the line is hard, the difference is not noticed by the majority of travelers. Whether the rigidity of these high rails will be more detrimental to themselves than the constant bending on cross-sleepers, time will have to show. If this disadvantage should manifest itself, it could be met by increasing the elasticity of the springs; on the other hand, the rigid surface offers a saving of traction power and wear of wheels, considering that with rails bending between sleepers every wheel practically runs on an inclined plane. It may be urged that, if once the rail heads should be worn out, the whole system will require renewal, but as an extensive experience with steel headed rails in Prussia, during 14 years, has shown that the life of a good rail, even under very onerous circumcumstances of traffic, is about 21 years, this objection falls to the ground, the more so since the rails of the present day, on wooden sleepers, have already reached the same weight per yard as our whole system without sleepers."

In the beginning of the year 1864 the Hoerder works, in Westphalia, supplied the Brunswick Railway with the two systems of iron permanent ways represented by Figs. 2 and 3, each of about 1100 yards in length, and some time afterwards with another variety of the same system, represented by Fig. 4.

The two first are lying side by side on the distance between Brunswick and Wolfenbuttel, that portion of the main line from the west to Berlin on which the wear of oak sleepers and the general repairs of the permanent way had been the heaviest of the whole distance between Cologne and Berlin.

The three systems embody the principle of supporting the head of the rail between the vertical arms of two angle-bars, riveted together, and held to gauge by cross-bars, the dimensions and distance of which, as well as of the angle-bars themselves, being varied in order to ascertain the maximum limit of saving material which may be approached without jeopardising the efficiency of the construction.

In the system shown in Fig. 2, the longitudinal rectangular angle-bearers measure 6 in. × 6 in. × ½ in., and are placed half an inch apart, to allow the web of the head rail to slip in. The gauge, or cross-bars of T iron 4 in. × 3 in. × ⅜ in. are placed five feet apart, and are riveted below to both the horizontal arms of the angle-bars.

In sytem No. 3 (Fig. 3) the rail-bearers are formed by angle-bars of 93°, the dimensions of which are reduced to 5¼ in. × 5¼ in. × ½ in., the head-rail, head-bolts, and their distance apart being the same as in system No. 2; but the cross-bars, here placed only three feet apart, were made of flat bar 3 in. × ½ in., ending in a T section, which is riveted through the two arms of the rail-bearers. In order to prevent the squeezing together of the latter, a half-inch fillet-plate is inserted between them. The fishing of joints is effected as in system No. 2, and the horizontal-bearing surface is 274 square inches per running foot of railway.

On the wear of the railway, the engineer, Mr. Scheffler, reports as follows: "The two systems lie side by side in a straight line, half the distance being on well-drained large gravel, the other half in fine gravel mixed with clay, very impermeable to the percolation of water. Both lengths have been worked for more than two years, and are in excellent preservation, continuing to bear a heavy express, passenger, goods, and mineral traffic. The state of the rails has been uninterruptedly satisfactory, and they have not required the same labor of keeping up which was necessary for the other portion of the railway. This contrast was especially remarkable in winter during a prolonged low temperature. After the thaw in the spring of 1865, only in the system No. 3, in those portions of the line where the ballast is unusually bad and clayey, a few instances of sinking occurred, but not to the same extent as on the line with cross wooden sleepers; however, on the larger portion of system No. 3, and on the whole of system No. 2, no packing or adjusting of any kind has been necessary. This favorable result is, perhaps, to be ascribed to the great height of the rail-bearers, which permit the bearing surface to lie deep in the ballast, and reduce the influence of frost on the base of the rail. The packing and lifting, when required, are an easy operation, and these constructions have shown no instability—a gratifying fact, since eminent engineering authorities, looking at the flat base of the rail-bearers, predicted a shifting sideways of the whole line. After two years' heavy traffic no displacement has been perceptible; all the component parts of the iron permanent way are in their original good condition; not a single rivet has worn loose, but the nuts of the head-bolts require now and then to be tightened with a spanner, as in those

of the fish-plates of the ordinary construction. The iron, including the portion submerged in the ballast, has been oxidized to a trifling extent, and hitherto experience has not justified the preference of one system over the other. The motion on both systems is a little harder, but, at the same time, much more steady and smooth, than on the most carefully constructed permanent way with wooden sleepers. Hitherto it has been impossible to note any difference in the motion of the carriages during the various influences of extreme heat or cold, it is the same in winter as in summer. In the manufacture of the rail-bearers for sytems Nos. 2 and 3, the Hoerder works found a difficulty in rolling the top of the vertical arm to a sufficiently clear edge, and this inconvenience necessitated their being planed. In order to obviate this expensive operation, the Hoerder works proposed to roll the top of the vertical arm with a bulb or rib, which allows a true edge to be produced without any further mechanical finishing. The Brunswick Railway thereupon resolved to adopt this bulb angle in their last system, No. 4 (Fig. 4), embodying the weight of the smaller section No. 3, which in practice had proved sufficiently strong, at the same time giving a conical form to the head bolt, in order, when tightening the nut, to press the head rail down on the rail-bearers. This head is made of cast steel. While keeping to the weight of the former section they increased the height of the vertical arm to $6\frac{1}{2}$ inches, the horizontal arm to $5\frac{1}{2}$ inches, the thickness of both being $\frac{3}{8}$ths of an inch full. Another deviation from systems No. 2 and 3 is the form of the cross-bars, which are of channel or C iron, 4 in. $\times$ $1\frac{3}{4}$ in. $\times$ $\frac{3}{8}$ths of an inch, placed five feet apart, as in system No. 2, and are fastened with bolts and nuts through the two vertical rail-bearers. The horizontal supporting surface of this system is 306 square inches per running foot of railway. It does not appear advisable to place the cross-bars at a greater distance from each other, since they not only serve to keep the line to gauge, but also contribute in holding each pair of rail-bearers together to prevent their buckling; and, at all events, the greater rigidity of the system compensates for the trifling, if perhaps superfluous, outlay. Experience will teach us the maximum distance of the cross-bars, and also whether a large number and their submersion in the ballast offer (as we have hitherto found) a sufficient resistance to the supposed tendency of the railway to move sideways, or whether it is advisable, for additional security, to adopt keel-fishes. The cost of the iron permanent way, exclusive of ballast and laying down, has been 36*s.* per yard, or, with laying down, £3200 per mile, as against 25*s.* per yard, or £2250 per mile for the ordinary construction with wooden sleepers. The weight of the three systems is—No. 2, per yard, 354 lbs.; No. 3, 295; No. 4, 300. The Hoerder works supplied the materials for systems Nos. 2 and 3 at £13 5*s.* per ton, delivered at Brunswick; but for system No. 4 stipulated an advance of 5*s.* per ton, on account of the wider dimensions of the angle-bars, which necessitated the use of better iron. The building up and laying of the permanent way, after the laborers got used to the work, pro-

Fig 1.

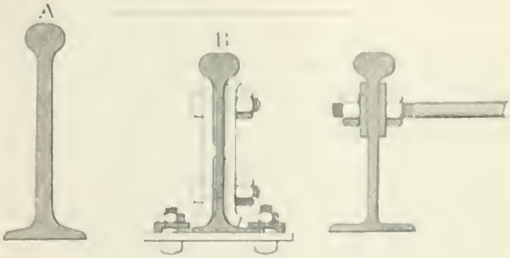


Fig 3.

Fig 2.

Fig 4.

Fig.5.

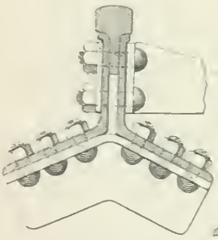


Fig.6.

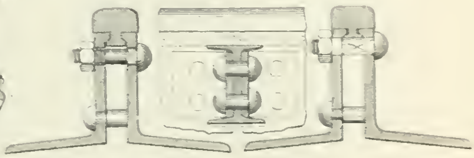
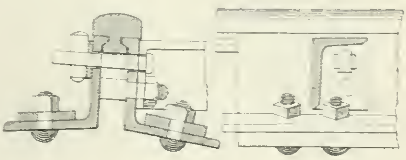


Fig.7.



gressed rapidly; the cost of laying down was 10*d.* per yard as against 7*d.* per yard for the old system. The ballast under the iron way is of the same depth as that under the wooden sleepers, viz., 12 inches, and practice has shown this to be sufficient.

"The experience of two years has not yet furnished conclusive data exactly to fix the cost of keeping up the line, but we have found—

"1. That packing has been much less needed than with the ordinary cross-sleepers, and the expenses under this head are merely nominal.

"2. The rails have not required any repairs; neither head-rail nor rail-bearers have been renewed or altered; and it is remarkable that the rail-ends have suffered much less (owing to their uniform support) than on the cross-sleepers.

"The principle of longitudinal construction is, in theory, the most correct, and is borne out by practice. The even continuous bearing is of immense importance to the permanent way, as well as to the rolling stock, and gives a much easier motion to engines and carriages.

"The uniform rigidity of this rail system, and the perfect support of the head-rails, show a marked improvement in the wear of the heads. The use of rivets—in places where frequent renewals are not likely to occur, as in parts covered by the ballast, and therefore not much shaken—is not objectionable. The number of component parts is not large, their connection is easily established, and practice has proved the construction to be strong. The rigidity of the iron permanent way, both vertically and horizontally, is much greater than that of the cross-sleepers. This is proved, not only by the analysis of form and dimensions of the section, but also by the steady motion of the rolling stock, and this advantage is conspicuous in express and heavy mineral trains."

Thus far Mr. Scheffler. After the favorable experience obtained on the Brunswick line, the Hanoverian, Cologne-Minden, the Saxon and Wurtemburg State railways, have resolved to .lay down experimental lengths of iron permanent way, constructed on analagous principles.

The Hanoverian system, illustrated by Fig. 5, was made by the Hoerder works, according to the specifications of the engineer of the line, but it does not appear to offer any advantage in theory, while its cost is much higher than that of the Brunswick system. The Hanoverian permanent way has the same cast-steel head as system No. 4; but the rail-bearers, ½ inch thick, are formed of angle-bars of 115°, 5½ inches high, and 6½ inches base, giving a horizontal bearing of 12 inches wide, equal to 288 square inches per running foot of railway.

The rail-bearers are riveted together, with a fillet plate, as in system No. 3. The head-bolts, conical, as in system No. 4, placed 18 inches apart, have a collar under the nut, which, pressing the rib of the angle, counteracts the supposed tendency of the head-rail to incline outwards.

The bars, 3 feet apart, of 3 inches × ¾ inch flat bar, are, as in system No. 3, riveted with T angles to the angle-bearers. The keel fish-

plates are formed of T iron, 5 inches $\times 2\frac{1}{2}$ inches $\times \frac{1}{2}$ inch. About five miles of this iron permanent way were laid down in 1866, which give a very satisfactory result; they will, however, only be thoroughly reported on after next spring.

A variation of the iron permanent way of systems Nos. 3 and 4, is now being constructed at Hoerde for some German railways, on a plan patented in this country by the author, and the advantage of which was developed during the manufacture of the material for the Brunswick and Hanoverian way. (Models, full and half size, were on the table.) When the metal used for the head-rail was changed from the use of the iron to the use of cast-steel, it was no longer practicable to punch the bolt holes in the web, and every hole had, at considerable expense, to be bored and slotted out.

Besides, under all circumstances, particular care was required in correctly adjusting the holes in the web with those of the rail-bearers. These combined considerations made it desirable to devise a system establishing a direct and strong connection of the head-rail and rail-bearers, without the head bolts passing through both, and led to the combination illustrated by Figs. 6 and 7.

The bulb or rib of the vertical arm instead of being placed outside, as in the Brunswick permanent way, No. 4, is here turned inwards, and is rolled into a dwarfed T section, thus forming a groove into which the ribs or bulbs of the rail-bearer gripe; and the whole system is tightened and firmly held together by the screw bolts, or wedge keys, passing through the rail-bearers under the head without touching the web at all. The head bolts are placed 20 inches apart; and in order to prevent their pressing the angle-bars closer together than necessary, a stop rivet is placed under each of them near the throat of the angle, which thus keeps each pair of rail-bearers at the proper distance from each other.

In Fig. 7 a plan is suggested to effect economy of material by slightly reducing the height of the rail, and replacing expensive screw bolts with cheaper keys and wedges, all of which can be simply rolled as a bar and cut off to the requisite size.

The cross-bars of these systems can, of course, be made of any section of iron. Those now making are partly of double T iron, partly of angle iron, bolted to the inner arm of the construction. By these means the outer arm of the rail-bearer can at all times be removed for the purpose of shifting, reversing, or renewing the head rail, without disturbing the gauge of the railway. The cross bars are most conveniently fitted near the end of the rail-bearers, where they contribute to stiffen the fish-joint, and at the same time serve admirably as supports of the points, which move easily over the flat surface of the cross bar.

In order to prevent the sliding backwards and forwards of the head rail by the friction of the wheel, a square stop bolt is applied to the head, passing through a notch in the web at each end of the rail. A few holes are punched here and there in tbe horizontal arm of the rail-bearer to assist in draining the ballast.

It is scarcely necessary to urge anything in favor of the principle of longitudinal permanent way generally. In some countries the first cost may appear greater; but the ever-increasing expense of keeping up wooden sleepers, especially in hot climates; the interruption of and danger to traffic during repairs; and, on the other hand, the advantages offered by the iron way of decreased wear of rolling stock, as well as increased safety and comfort in traveling, are considerations of such importance as to render the abandonment of the present cross-sleeper construction merely a matter of time.

In the systems just described the life of the iron parts is practically unlimited. The only portion subject to gradual wear is the steel head, weighing about 34 lbs. to the yard; and this economical application of the more expensive material justifies the engineer in using crucible cast steel of a high class, instead of the cheaper but less durable Bessemer steel, which, for good financial reasons, is the only steel which railways have hitherto allowed themselves to use.

The weight of the new system, as per dimensions shown in Fig. 6, is 223 tons per mile; the cost, inclusive of laying at 9*d.* per yard, about £3100.

The weight of system No. 7 is 193 tons, and the cost about £2700 per mile of single railway. But these prices are based upon the use of high-class Prussian iron, at £12 to £14 per ton, and bolts from £24 to £30 per ton; with the use of English iron the cost per mile should not exceed £2200 per mile.

I would finally urge, in favor of the iron permanent way, the consideration that wood is getting scarcer and dearer every year, and may well be saved from decaying in the ballast, in order to fulfil the nobler mission of meeting the numerous wants of our domestic and social habits and dwellings. And if railways in England and its colonies were generally to adopt the iron permanent way, an immense impulse would again be given to an industry now unfortunately languishing, but the prosperity of which forms the back-bone of the wealth and power of this country.

Weight and Cost of System No. 6 per Mile, calculated on the price of Prussian Iron.

(PER LENGTH OF 20 FEET.)

				£.	s.	d.
2 head rails	460 lbs.,	at 16*s.* 6*d.*	cwt.	3	7	9
4 rail bearers	1180	" 12*s.* 0*d.*	"	6	5	7
3 cross bars	170	" 13*s.* 6*d.*	"	1	0	9
4 fish plates	26	" 12*s.* 0*d.*	"	0	3	0
62 bolts and nuts	48	" 30*s.* 0*d.*	"	0	12	9
22 stop bolts	8	" 24*s.* 0*d.*	"	0	1	9
	1892 lbs.			£11	11	7

	£	s.	d.
= per mile, 223 tons	£3056	18	0
Laying down, at 9*d.* per yard	66	0	0
Total	£3122	18	0

Weight and Cost of System No. 7 per Mile, calculated on the price of Prussian Iron.

(PER LENGTH OF 20 FEET.)

					£	s.	d.
2 head rails	460 lbs.,	at	16s. 6d.	cwt.	3	7	9
4 rail bearers	1050	"	12s. 0d.	"	5	12	6
4 cross bars	44	"	12s. 0d.	"	0	4	8
4 fish plates	26	"	12s. 0d.	"	0	3	0
26 wedges and cotters	37	"	18s. 0d.	"	0	5	11
18 stop bolts	7	"	24s. 0d.	"	0	1	6
16 bolts and nuts	16	"	30s. 0d.	"	0	4	0
	1640				£9	19	4

= per mile, 193 tons	£2631	4	0
Laying down, at 8*d.* per yard	57	0	0
Total	£2688	4	0

THE USE OF ANTHRACITE COAL AS A FUEL.

By P. W. SHEAFER, Engineer of Mines, Pottsville, Pa.

THE accompanying anthracite coal monument [Plate V.] represents the wonderful and recent appreciation of this kind of fuel.

That portion of Pennsylvania purchased from the Indians at a treaty in Philadelphia on the 22d August, 1749, for £500, embraced all of the middle and southern coal fields included in all that district north of the Blue Mountains, and extending from the Lehigh to the Susquehanna rivers. The northern, or Wyoming and Lackawanna coal districts, were included in the Fort Stanwix purchase of November 5, 1768, which great area, reaching from the south-western to the north-eastern boundaries of Pennsylvania, cost $10,000.

The following data show how anthracite coal struggled into recognition as a fuel:

In 1768 anthracite coal was first used in Wyoming Valley by Obadiah Gore, (blacksmith.)

In 1775 and '76—several boat loads of anthracite coal were sent from Wyoming down the Susquehanna, and thence hauled to Carlisle barracks, to manufacture arms.

In 1790—coal first known in Schuylkill county.

In 1794—blacksmiths used it in Schuylkill county.

In 1808—used in grates by Judge Fell, of Wilkesbarre.

Year	Lehigh	Schuy	Wyoming	Shamokin Harr[illegible] Trevorton	Total Tons
1820	Tons 365		Tons	Tons	Tons 365
1821	1.073				1 073
1822	2.240	1			3 720
1823	5 823	1			6.951
1824	9 541	)			11 108
1825	28 393	6			34 893
1826	31 280	16			48 047
1827	32.074	31			63 434
1828	30 232	47			77 516
1829	25.110	79	7 000		112 083
1830	41 750	89	43 000		174 734
1831	40 966	81	54 000		176 820
1832	70,000	209	84 600		363 871
1833	123 000	252	111 777		487 748
1834	106 244	226	43 700		376 636
1835	131.250	339	90 000		560 758
1836	148.211	432	103.861		684 117
1837	223 902	523	115 387		879 444
1838	213 615	433	78 207		738 697
1839	221.025	442	122 300	11 930	818 402
1840	225.318	452	148 470	15 005	864 384
1841	143 037	58	192 270	21 463	959 973
1842	272.546	54	252 599	10 000	1 108 418
1843	267.793	67	285 605	10 000	1 263.598
1844	371 002	84	365 911	13.087	1 630.850
1845	429 453	1 08	451 836	10.000	2 013 013
1846	517.116	1 23	518.389	12 572	2 344 005
1847	633.507	1 58	583.067	14 904	2.882.309
1848	670.321	1 65	685.196	19.356	3 089 238
1849	781.656	1 60	732.910	45.075	3 242 966
1850	690.456	1 71	827 823	57.684	3 358.899
1851	964.224	2 22	1.156.167	99.099	4 403 730
1852	1 072.136	2 45	1.284 500	119.342	4 993.471
1853	1.054.309	2 47	1475 732	113.007	5 195.151
1854	1 207.186	2.89	1603 478	234 000	6 002.334
1855	1 284.113	3.31	1.771.511	240 338	6 604 318
1856	1.351.970	3 25	1.972 581	313 444	6 927.580
1857	1.318 541	2 98	1.952 603	388 255	6.663.828
1858	1.380.030	2.88	2186 094	370 424	6 759 369
1859	1.628.311	3 00	2.731 236	443 755	7.780 518
1860	1.821 674	3 27	2.941 817	479 116	8.412 946
1861	1 738 377	2 69	3.055 140	463 308	7 843 211
1862	1 351.054	2 89	3145.770	481 990	7 739 899
1863	1.894 713	3 43	3.759 610	478 418	9 631 101
1864	2 054 669	3 64	3.960 836	519 752	10 184.320
1865	2.040 913	3 73	3.254 519	621 157	9 652.391
1866	2.179.364	4.95	4736.616	830 722	12 703.882

Progress of the Anthracite Coal Trade of Pennsylvania.

By P. W. Sheafer,

Engineer of Mines Pottsville Penna.

Year	Lehigh	Schuylkill	Wyoming:	Shamokin Wiconisco & Trevorton:	Total Tons.
	Tons		Tons	Tons	Tons
1820	365				365
1821	1 073				1 073
1822	2.240	1 480			3 720
1823	5.823	1 128			6.951
1824	9 541	1 567			11.108
1825	28,393	6.500			34 893
1826	31 280	16. 767			48.047
1827	32.074	31. 360			63.434
1828	30,232	47. 284			77.516
1829	25.110	79.973	7.000		112.083
1830	41 750	89 984	43.000		174 734
1831	40.966	81 854	54 000		176.820
1832	70,000	209 271	84 600		363.871
1833	123.000	252 971	111 777		487.748
1834	106.244	226, 692	43 700		376,636
1835	131, 250	339, 508	90 000		560. 758
1836	148.211	432. 405	103. 861		684 117
1837	223.902	523, 152	115 387		879.444
1838	213.615	433. 875	78. 207		738 697
1839	221 025	442. 608	122 300	11,930	818. 402
1840	225.318	452. 291	148 470	15.005	864 384
1841	143.037	585. 542	192. 270	21 463	959 973
1842	272.546	541. 504	252 599	10 000	1. 108. 418
1843	267 793	677 312	285 605	10 000	1. 263. 598
1844	371 002	840. 378	365 911	13.087	1 630. 850
1845	429 453	1 083. 796	451. 836	10,000	2.013 013
1846	517. 116	1. 236. 582	518. 389	12.572	2.344 005
1847	633,507	1 583 374	583, 067	14 904	2. 882.309
1848	670 321	1 652 835	685. 196	19. 356	3. 089. 238
1849	781 656	1. 605 126	732. 910	45,075	3 242. 966
1850	690.456	1 712. 007	827 823	57.684	3. 358. 899
1851	964.224	2 229. 426	1. 156. 167	99.099	4 403. 730
1852	1 072.136	2 450. 950	1. 284 500	119,342	4 993. 471
1853	1 054 309	2. 470 943	1.475 732	113,007	5 195 151
1854	1 207. 186	2 895 208	1603. 478	234 000	6.002. 334
1855	1 284. 113	3.318 555	1.771. 511	240.338	6.604 318
1856	1 351. 970	3. 258 356	1,972 581	313 444	6.927 580
1857	1.318 541	2 985. 541	1.952 603	388 255	6. 663. 828
1858	1.380.030	2 886 449	2 186. 094	370 424	6. 759 369
1859	1 628. 311	3 004 953	2.731 236	443 755	7. 780 518
1860	1 821 674	3 270. 516	2.941 817	479 116	8. 412. 946
1861	1. 738 377	2 697 489	3 055. 140	463. 308	7. 843 211
1862	1 351 054	2 890. 598	3.145. 770	481. 990	7. 739. 899
1863	1.894 713	3 433. 265	3. 759 610	478 418	9 631, 101
1864	2 054 669	3 642. 218	3.960. 836	519. 752	10, 184. 320
1865	2.040 913	3 735. 802	3 254 519	621. 157	9 652 301
1866	2.179. 364	4. 957. 180	4736.616	830, 722	12. 703. 882

In 1812—Col. Geo. Shoemaker hauled nine wagon loads of coal from Pottsville to Philadelphia, and gave away the coal.

In 1814—Charles Miner sent an ark load (24 tons) of coal from Mauch Chunk *via* the Lehigh and Delaware, to Philadelphia.

In 1815—Schuylkill navigation commenced.

In 1820—365 tons of coal were shipped by the Lehigh canal.

The coal product in	1820 was	365 tons,	equal to	1 ton	per diem.
"	"	1830	174,734	"	479	"
"	"	1840	864,384	"	2,368	"
"	"	1850	3,358,899	"	9,203	"
"	"	1860	8,412,946	"	23,049	"
"	"	1866	12,703,882	"	34,805	"

The increase per diem has been almost one hundred-fold in forty-six years.

The comparison between the population of the United States and the anthracite product of Pennsylvania, shows a gratifying increase in regard to both.

	Population.	Coal product.				
1820............	9,683,131	365	tons, or	25,529	capita	per ton.
1830............	12,866,020	174,734	"	73·6	"	"
1840............	17,069,453	804,384	"	19·5	"	"
1850............	23,191,876	3,358,899	"	6·5	"	"
1860............	31,641,977	8,412,946	"	3·8	"	"

The increase of population is so great that we can hardly expect the product of coal in 1870, to be three persons per ton of coal, and when it will be one person per ton, who can tell?

The gross product of anthracite coal from 1820 to 1866, inclusive, amounts to 149,876,119 tons.

The areas of the several coal districts are nearly as follows:

THE FIRST SOUTHERN OR SCHUYLKILL COAL FIELD.

1. East of Tamaqua mostly covered by the lands of the Lehigh Coal Navigation Company...............	16	square miles,	10,240	acres.
2. Tamaqua to Pottsville....................	36	"	23,040	"
3. Pottsville west, to Forks of Basin	55	"	35,200	"
4. North Fork, or Lykens Val. Prong	16	"	10,240	"
5. South Fork, or Dauphin Prong....	15	"	9,600	"
6. North Mine Hill Range...............	8	"	5,120	"
Total area of Southern coal field	146	"	93,440	"

THE SECOND OR MIDDLE COAL FIELD.

1. Shamokin District	50	square miles,	32,000 acres.
2. Mahanoy "	41	"	26,240 "
3. Beaver Meadow, Hazleton, Big and Little Black Creek	35	"	22,400 "
Total area of second coal field	126	"	80,640 "
The 3d Northern or Wyoming and Lackawanna coal field	198	"	126,720 "
Total area of the anthracite coal fields	470	"	300,800 "

The average yield per acre thus shown in forty-six years, amounts to nearly 500 tons. The inquiry naturally follows as to how much remains. In former calculations, we made the coal thickness of the

Southern coal field to be	25 yards.
Middle "	15 "
Northern "	15 "

These sums, multiplied by the number of acres in each field, give the following results:

In the first coal field	11,308,824,000	cubic yards	or tons.
" second "	5,854,964,000	"	"
" third "	9,179,872,000	"	"
Total	26,343,660,000	"	"
Deduct half for waste in mining and breaking	13,171,830,000	"	"
Balance	13,171,830,000	"	"
Deduct amount mined in forty-six years	149,876,119	"	"
Balance on hand	13,021,953,881	"	"

equal to 43,291 tons per acre.

These figures give an amount of coal "in the hold," equal to a demand of 20,000,000 per annum for 651½ years in the future.

The correctness of these data may be brought into question, but not fairly disputed.

The coal area is well defined and correctly shown on our maps; the coal thickness for each coal field is not over-estimated, and the deduction of one-half from the gross amount, should cover all waste incident to our extravagant and careless mode of mining, and the yet more improvident waste in the preparation of coal for market. I have estimated 20,000,000 tons per annum for a future demand; this amount is assumed by some as the maximum product of our mines.

I can hardly believe it to be our limit. With so grand a supply at our command, with all the modern and improved appliances for extracting coal from the mines, with more numerous shafts, slopes, tunnels and drifts, and, more than all, the indomitable energy and skill of our people, we can scarcely imagine a demand to which we are not equal.

COFFER-DAM AT TURNER'S FALLS,

On the Connecticut River.

By James B. Francis, Civil Engineer.

Turner's Falls are situated in the towns of Gill and Montague, Massachusetts, about a hundred miles from the mouth of the river. The fall, which with the rapids below, is about sixty feet, is produced by a ridge of the new red sandstone, well-known to geologists as affording fossil foot-prints in great numbers and variety.

In the year 1792, the Proprietors of the locks and canals on Connecticut River were incorporated by the State of Massachusetts, for the purpose of making certain parts of the river navigable for boats and rafts. Within a few years after the passage of this Act, a canal about three miles in length, was made in Montague, around Turner's Falls; a considerable portion of the capital required having been furnished by Dutch capitalists. This investment gave profitable returns for many years, but the exhaustion of the timber in the upper parts of the valley, and the construction of railroads, led to its abandonment for navigation purposes. In 1866, the stock having passed into new hands, the name of the corporation was changed to the Turner's Falls Company, and they were authorized to increase their capital to $1,000,000; the object of the new company being to develop the vast water-power furnished by the Connecticut River at this point, and thereby build up a large manufacturing city.

A dam had been maintained for many years by the old Navigation Company, but since the disuse of the canal, one-half of it had been carried away, and the remainder had become greatly dilapidated. The first work undertaken by the Turner's Falls Company, was to construct a new dam across the river, about twenty-three feet in height and nine hundred feet in length, of timber and stone.

At the site of the dam the river is divided into two branches by a rocky island about forty feet high. The part of the old dam still remaining, was between this island and the Gill shore, diverting the

entire flow, in ordinary stages of the river, to the channel on the Montague side of the island. Advantage was taken of this to construct the dam on the Gill side, before doing anything on the Montague side, the new dam being built a short distance below the old one. This part of the new dam was so constructed that the water could be turned through it, so as to enable the part on the Montague side to be built without making a coffer-dam high enough to turn the water over the top of the finished part of the dam on the Gill side. For this purpose, about two hundred feet in length was left about twelve feet below the level of the top of the finished part of the dam. To enable this opening to be built up when the dam on the Montague side was completed, large timbers were placed vertically from the toe of the dam, about eight feet apart, and supported by tie-rods, anchored to the rock. While the dam on the Montague side was being built, it was designed that the whole flow of the river should pass between these timbers and through the opening in the dam; and when the other part of the dam was completed, the flow through the opening should be stopped and the water turned over the top of the finished dam, by planking up the timbers put in for that purpose. During October, 1866, the coffer-dam on the Montague side was completed, and the entire flow of the river was diverted through the opening on the Gill side. On the 31st of that month, however, there was a freshet, which brought down trees and stumps, and broke away some rafts of timber intended for the new dam. These came against the vertical timbers, breaking them off, and the great volume of water rushing through the opening washed out the substructure of the dam, clean to the rock, for about one hundred and ten feet in width. On the subsidence of the freshet, work was resumed on the Montague side, the river flowing through the breach on the Gill side, and by the middle of December the dam on the Montague side was completed.

And now came the interesting question, what was to be done with the breach in the dam? If it was allowed to remain until another season, there was great reason to fear that the whole of the section on the Gill side of the island would be carried away when the ice broke up in the spring. On the other hand, to fill up the breach during the winter seemed to be scarcely practicable, the great difficulty being to divert the flow of water from the breach. This could only be done by turning it over the top of the finished part of the dam; but, in order to do this, the water must be raised twelve or fifteen feet, by means of a coffer-dam, above the breach, directly in the

current. This coffer-dam must be built and the breach filled up before the ice broke up in the spring, otherwise it was deemed certain that all that might be done would be carried away. The Connecticut river is subject to freshets at all seasons of the year. In the winter, a thaw of a few days will often break up the ice in some of the tributaries, carrying it into the main river, where it accumulates and subsequently freezes together, so that when a high freshet occurs in the main river, masses of ice, often exceeding ten feet in thickness, are carried down with the current. Such a freshet is looked for every year, in January or February, and and if one occurred before the breach could be filled, it would render useless all that might be done. Then there was the difficulty of doing any work, in the water, in a climate of such severity as that of Northern Massachusetts, to say nothing of the short days. However, the practical men who would have the work to do, were willing to attempt it, and felt confident that if they escaped a winter freshet, they could accomplish it. It was accordingly decided by the directors of the company to make the attempt.

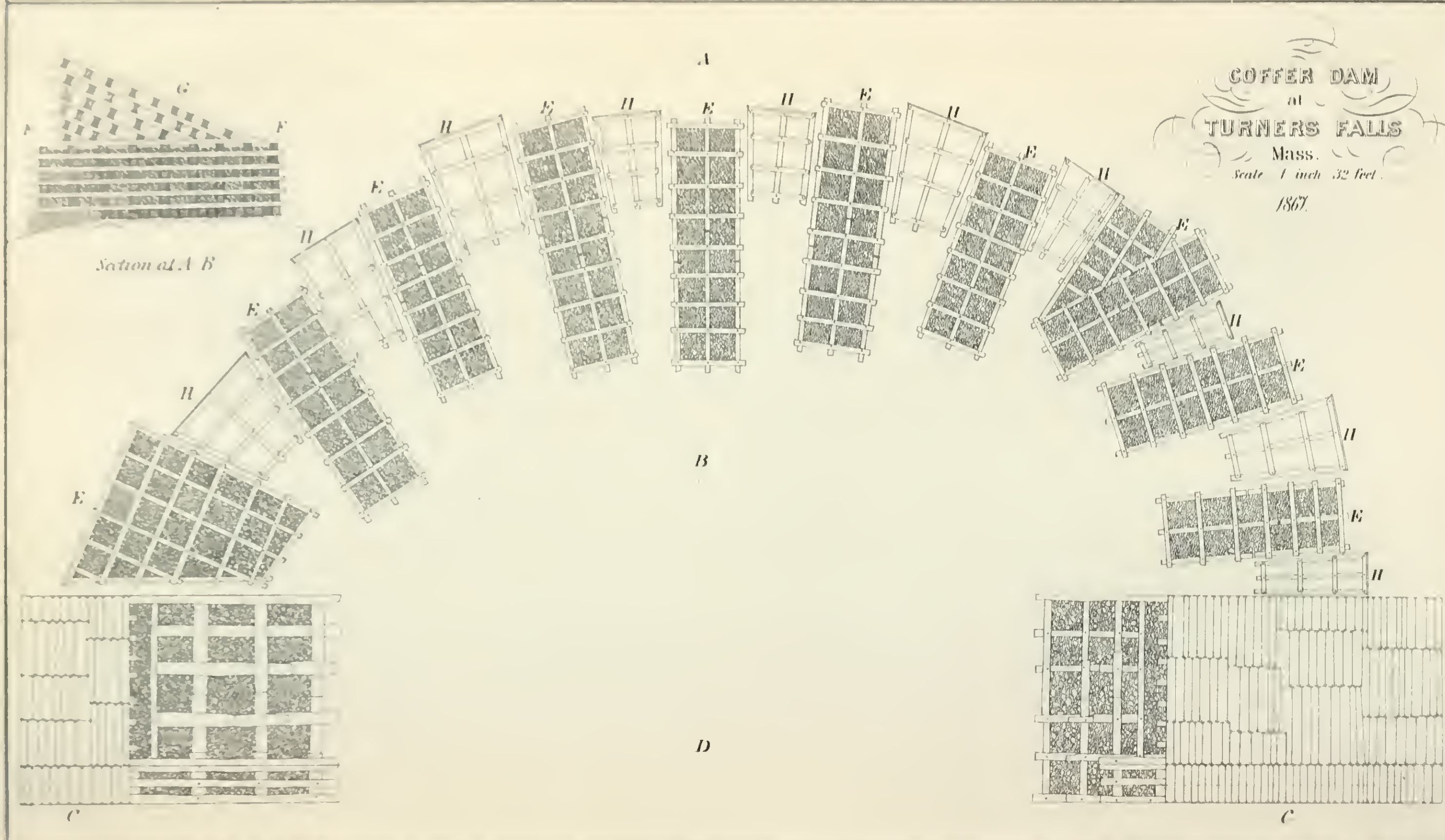
The coffer-dam* was devised by Mr. George W. Potter, of Greenfield, Massachusetts, the agent of the company, and Mr. Alonzo P. Richardson, of Pishon's Ferry, Kennebec Co., Maine, the superintendent of the work. Plate VII. is a plan and section of the coffer-dam. C C is the finished dam on each side of the breach; D, the breach through which the entire volume of the river must continue to flow, until it could be turned over the finished parts of the dam. The flow of the river, while the work was in progress, is estimated as varying from about 5000 to 10,000 cubic feet per second, the depth of the water in the breach varying from 5 to 8 feet, and its velocity from 10 to 12 feet per second, excepting during one freshet, to be noticed hereafter, when it was much greater. E, E, E, are cribs, built of timbers, about a foot square, taken from the remains of an old dam. These cribs were framed on the shore and floated to their places, being held in the current by strong guys; when in the desired position, they were filled with stone, which gave them sufficient stability to retain their position without aid from the guys. These cribs rested on the rock, and after being placed and loaded, were built up

* The term *coffer-dam* strictly means a dam formed of a double row of piling, with the space filled with a water-tight puddle; latterly the term appears to be applied to a dam of any construction for the purpose of enabling any work to be done under water.

to a uniform height, F F, (see the section in Plate VII.) which was above the level of the water, which flowed through the spaces between the cribs, and through the interstices in the wood and stone work. A platform of timber was then laid on top of the cribs, covering also the spaces between them; on top of this platform was built a dam, G, sloping up stream 2·5 horizontal to 1 vertical, as represented in the section, the slope being planked, and the top of it being about 3·5 feet above the top of the finished part of the dam; making the whole height of the coffer-dam about twenty-five feet. The next thing was to stop the flow through the ten openings between the cribs; this was done by means of the plugs, H, H, H, which were framed to fit the spaces they were intended to close; planked tight on their up-stream ends, and floated to their respective positions by means of guys. Great quantities of stone, brush and gravel were then thrown in on the upper side of the cribs, which stopped nearly all the leakage and diverted the flow over the finished parts of the dam.

The first crib was placed Deeember 31, 1866, and the last on the 16th of January following. The last plug was put in on the 1st of February. The remainder of February was occupied in tightening up with stone, brush and gravel. March 1st, the filling up of the breach in the main dam was commenced, and was completed on the 22d of that month. Fortunately, there was no freshet sufficient to break up the ice in the main river while the work was in progress. February 11th, the water was high, being about six feet on the crest of the finished part of the dam, and about 2·5 feet above the top of the coffer-dam, doing, however, no material injury, further than to cause a suspension of the work for a few days. About seventy men were employed, and notwithstanding the extreme severity of the weather during January, the temperature, much of the time, being below zero, there was no unusual sickness among the men, and no life was lost, or any serious accident occurred. Two of the piers were lost while floating them to their places, by the breaking of the guys.

Thus was happily completed a work remarkable for boldness and ingenuity of design, simplicity of means, and skill and courage in execution, under the most difficult and hazardous circumstances. The entire credit must be given to Messrs. Potter and Richardson, who designed it, and, with the assistance of a gang of hardy and resolute men, executed it; and to the Hon. Alvah Crocker, of Fitchburg, the President, and Wendell T. Davis, Esq., of Greenfield, the resident director of the company, who had the courage to proceed under such circumstances, and who brought out the full energies of their men by their confidence and encouragement.


COFFER DAM
at
TURNERS FALLS
Mass.
Scale 1 inch 32 feet.
1867.
Section at A B
A
B
C
C
D
E
F
F
G
H

Mechanics, Physics and Chemistry.

(Continued from page 193.)

LECTURES ON VENTILATION.

Delivered before the Franklin Institute, by L. W. Leeds, Esq.

LECTURE II.

As I stated at our last lecture, much interest is being awakened, in this country and in Europe, by recent investigations showing the enormous numbers of untimely deaths that are caused throughout all classes of society by foul air.

It would have been a startling announcement, ten years ago, to have stated that impure air caused as many deaths, and as much sickness, as all other causes combined, and yet the most diligent and accurate investigations are rapidly approaching that conclusion.

Few really comprehend the immense pecuniary loss, saying nothing of the amount of suffering that we endure by this extra and easily preventible amount of sickness.

I propose, this evening, to enter upon the consideration of one of the most important parts of our subject—*the effect produced by* HEAT *upon the movements of air.*

I think it probable that many of us do not comprehend the actual reality of the air.

We are apt to say of a room that has no carpet or furniture in it, that it has nothing in it, while, if it is full of air, it has a great deal in it.

A room between twenty-seven and twenty-eight feet square contains one ton of air—a real ton, just as heavy as a ton of coal. Now, there is not only twenty-seven feet, but more than twenty-seven miles of air piled on top of us. The pressure of the atmosphere at the level of the ocean is about fifteen pounds to the square inch. An ordinary sized man sustains a pressure of about fifteen tons, and were it not that this pressure is equal in all directions, we would be crushed thereby.

We must accustom our minds, therefore, to consider air a real substance, and that it is as totally unable to move itself, or of being moved, without *power*, as water or coal. It requires just as much

power to move a ton of *air* from the cellar to the second story, as it does a ton of coal.

Heat is the great moving power of air. Those whose attention has not been especially directed to the subject of the amount of power exerted by the sun's rays upon the earth, have little conception of its magnitude.

The power of all the horses in the world, added to the power of all the locomotives, and of all the immense steam engines in all the world, express but a small fraction of the power exerted by the sun's rays upon the earth. It is estimated to be sufficient to boil five cubic miles of ice-cold water every minute.

His rays are the chosen power of the Creator for moving all matter upon the globe. It is his rays that lie buried in the vast coal fields beneath the earth. His rays cause every spear of grass to grow, rears the mighty oak, forms the rose, bursts its beautiful buds, and sends its perfume through the air.

No bird warbles its sweet music in the air, no insect breathes, save by his power, and all animals love to bask in the genial glow of his light and heat. He rolls the scorching air of the tropics to frozen lands, wafts the ships across the seas. He forces the heated waters of the equator to the poles, tempering all the earth. He lifts the water from the sea to sprinkle all the land and cap the distant mountains with eternal snow.

Now, let us examine a little more minutely how this influence is exerted upon the *air*, which is the subject we are especially interested in at present.

Does it commence at the top, and heat it, layer by layer, until it reaches the bottom? Not at all; but it passes through the whole forty-five miles of air, heating it very little, if any, and falls upon the solid substances at the earth's surface, heating them, which, in turn, heat the air by its individual particles coming in immediate contact with those solid hotter substances.

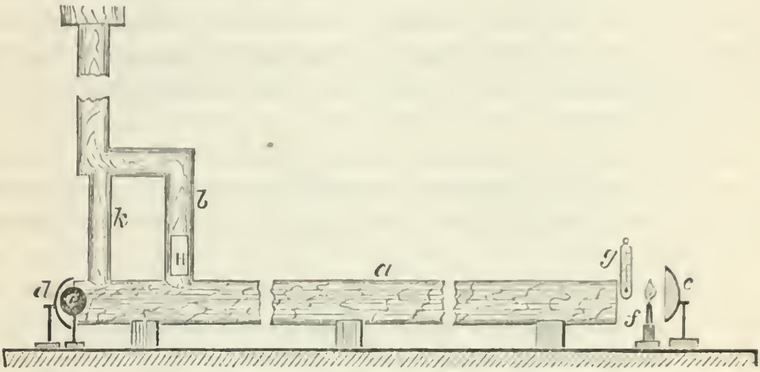
We will endeavor to illustrate this in a crude way.

Here we have a tin tube, A, fifteen feet long and ten inches in diameter, open at both ends; two feet from one end we introduce this ascending pipe, B, the upper end of which is merely inserted in a small flue, extending to the top of the building. The height of this flue is sufficient to make a current of air pass through this tube, as you will see by holding this smoking taper at the far end. We will now place a large heated ball, C, at this end, and outside of that we

will place this reflector, D, pressing it quite close to the end of the tube, so that no air can enter here.

The rays of heat from this ball, or from any other warm body, are thrown like rays of light, in every direction equally; there would,

Fig. 7.



therefore, be some of the rays thrown through this tube to the other end without any reflector, but the proportion that would reach the other end would, of course, be small.

We therefore collect those going the other way, and change their course, and then send them straight through the tube to the far end.

We will place another reflector, E, at the far end, to receive and concentrate those rays, in the focus of which we will place a candle, F, with a little phosphorus on it, to show you that the rays of heat are passing through.

There you see the candle is lighted, thus proving that there is a strong current of radiant heat coming from the hot ball, through the tube to this end. And you see by this smoke that there is a current of air passing the other way.

Now, we want to know how much that air is heated in passing the whole length of this tube against that shower of radiant heat, or whether air absorbs radiant heat at all; but, before going to the other end, where the hot ball is, we will take two thermometers that have been lying here, side by side, and both indicate a temperature of 69°. One of them, C, we will hang at this end, about opposite to the centre of our tube, which, I think, will give us a fair average of the entering air, first removing, however, the candle that has been lighted, and the reflector.

We will hang the other thermometer in the ascending tube, at the

end near the heated ball. We have had two glasses, H, inserted here, so we might observe what was going on within by the smoke from this taper. You see there is a strong current of air passing up the tube, all of which must come from the far end, flowing against the strong current of radiant heat going in the opposite direction. Now, leaving this thermometer to rise or fall according to the temperature of the air flowing through, we will go to the other end and examine another very interesting part of this experiment: it is the manner in which the radiant heat is received and appropriated by different substances.

Radiant heat is thrown from a hot body in every direction equally, but no two kinds of substances receive those rays of heat in the same manner, nor do they make the same use of them after they have received them.

Every substance receiving heat, however, must give a strict account of it. It must give out an equal amount of heat, or, what is taken as an equivalent, some action or power.

I have a sheet of ordinary tin, and as I hold this polished side behind this light, you see it throws a belt of light across the room, and as I put it in front of the end of our tube, and by turning it so the rays of heat will be reflected in your faces, I think some of you will be able to feel the reflected heat. The rays of heat are turned from their course, and thrown in a belt across the room, similar to the rays of light.

But you cannot give away and keep the same thing. This bright polished surface appropriates but a very small portion of the radiant heat. A thermometer hanging for some minutes against the back has scarcely risen one degree; but we have given the other side a coating of lamp black, with a little varnish, and by turning that side towards the pipe, the result will be quite different. By this coat of black varnish the whole character of the sheet of tin is changed. The black, however, has but little to do with it; if it was white, or red, or blue, the formation of the surface being similar in every respect, the result would be the same almost precisely.

Instead of acting merely as a guide-post, to *change* the *direction only* of the rays of heat, as before, it now becomes a receiving depot, absorbing nearly all the heat that comes to it. It must soon become filled, however. The thermometer hanging at the back has risen six degrees already, and is going up rapidly; it must soon begin to distribute its extra stores. But mark the different manner of distri-

buting the heat. Instead of *reflecting* the whole all in one direction, as when received on the other side, it now *radiates* them equally in every direction.

Some solid substances allow the rays, both of heat and light, to pass directly through them without either reflecting or absorbing them. Other substances allow the rays of light to pass through them, but absorb much of the radiant heat, like clear glass.

Rock salt is one of the best non-absobents of radiant heat, allowing nearly the whole of the rays of heat to pass through unobstructed.

We will now return to our experiment at the other end of the tube. I find there is something wrong here—the mercury in the thermometer has risen several degrees. I knew this was rather a crude arrangement for illustrating this very beautiful and interesting part of our subject, but I hoped it would assist me a little in conveying to you the idea I desired to impress upon your minds. I find, however, it is scarcely delicate enough to illustrate perfectly what I wanted to show.

But this increased temperature is not owing to the effect of radiant heat on the air coming from the far end, but I find by the heat at the top of the pipe, between the heated ball and this ascending pipe, I, and by the current of heated air on the side next the ball, that there is a current of *circulating air* that *has been heated* by coming in immediate *contact* with the hot ball.

I designed this smaller tube, K, to carry off the air thus heated, but it appears to be too small.

We ought to have had a piece of rock-salt to have closed the end of this tube, so that the radiant heat would have passed through without allowing any *circulation* of *heated air*, but I was unable to find such a piece. But Professor Tyndall, in his lectures before the Royal Institute of Great Britain, gives the results of a large number of very accurate and beautiful experiments tried for the purpose of determining whether the forty-five miles of atmosphere surrounding the earth absorbed *any* of the sun's rays, and if so, how much?

These experiments prove, in the most conclusive manner, that dry pure air is almost a perfect non-absorbent of radiant heat. Thus, were the air entirely dry and pure, the whole forty-five miles through which the sun's rays have to pass, would absorb a very small fraction thereof, so that in the length of our tube it would be but an exceedingly small fraction of one degree, that is, for pure dry air.

But is the air of this room pure and dry? Very far from it.

Professor Tyndall found that the moisture alone in the air of an ordinary room, absorbed from fifty to seventy times as much of the radiant heat as the air does. Air and the elementary gases—oxygen, hydrogen and nitrogen—have no power of absorbing radiant heat, but the compound gases have a very different effect; for instance, olifiant gas absorbs 7950 times as much as air; ammonia, 7260; sulphurous acid, 8800 times. Perfumes, also, have a wonderful power of absorbing radiant heat.

The moisture in the air, however, is of the greatest practical importance in various ways. It is the great governor or regulator or conservator of heat; it absorbs it and carries it from point to point and into places where the direct rays of the sun could not get; it is like a soft invisible blanket constantly wrapped around us, which protects us from too sudden heating or too sudden cooling.

Professor Tyndall, speaking of the moisture in the air, says: "Regarding the earth as a source of heat, no doubt at least ten per cent. of its heat is intercepted within ten feet of its surface." He also says: "The removal for a single summer's night of the aqueous vapor from the atmosphere which covers England, would be attended by the destruction of every plant which a freezing temperature could kill.

"In Sahara, where the soil is fire and the wind is flame, the refrigeration is painful to bear."

And in many of our furnace-heated houses, we have an atmosphere very similar in point of dryness to that of Sahara, but more impure.

The foregoing remarks in regard to the impossibility of heating air, apply especially to radiant heat. Air does become heated, but in a different manner; it is heated by each individual particle or atom coming in immediate contact with some hotter substance. See what a wonderful provision for creating a constant circulation of the air. The sun's rays pass through it without heating it, but heat the surface of the earth at the very bottom of the ocean of air; these in their turn, heat the air by each individual atom coming in immediate contact with these hotter substances, expanding them so that they must rise, thus enabling the colder and heavier particles to rush in and take their places. With this great universal moving cause, in connection with the innumerable minor causes resulting from the very different absorbing, radiating and reflecting powers of various substances, it becomes almost impossible for the air to be entirely and absolutely at rest, even in the most minute crack or cranny, or bottle corked air-tight.

Now, to apply these principles to every-day life, to the heating and ventilation of our houses, taking the *open fire* first, we find that acts like the sun, heating exclusively by direct radiation. The rays of heat fall upon the sides of the room, the floor and ceiling, and the solid substances in the room which thus become partially heated, and in their turn become *secondary radiators*. This radiant heat from the fire does not heat the air in the room at all, but the air becomes partially warmed by coming in immediate contact with the sides of the room, the furniture, &c.

One great reason, therefore, why an open fire is so much more healthy than any other means of artificial heating, is because it more nearly imitates the action of the sun.

The rays of heat fall upon our bodies, heating them, while it leaves the air cool, concentrated and invigorating for breathing. The bright glow of an open fire has a very cheering and animating effect. It produces a very agreeable and healthy excitement.

It is not improbable that future careful investigations may prove that there is an important change takes place in the electric or ozonic condition of air as it passes over, or in contact with, hot iron, which does not occur to the air of a room heated by the open fire.

The air in a room heated by an open fire can scarcely become stagnant, because that fire must necessarily be constantly drawing a considerable amount of air from the room to support combustion, the place of which will be supplied by other air, and here is where one of the greatest inconveniences arises in the use of the open fire; if the air entering to supply this exhaustion comes in at a crack of the door or window, on the opposite side of the room, and that air is cold, say 10° or 15° above zero, it flows across the floor to the fire, chilling the feet and back of those sitting in its track. It is quite possible to roast a goose or round of beef in front of a fire, while the air flowing by it into the fire is freezing cold. This should be remedied by having the air flowing in partially warmed before it enters, say to a temperature of 40° to 50°, either by having the halls overflowed by partially warmed air, and opening a door into it, or by admitting the air to enter around the back of the fire-place, as Dr. Franklin arranged it.

Thus, while an open fire is the healthiest known means of heating a small room, and should be in the family sitting-room of every house, and in offices and other places where the occupants are at liberty to move closer or further from the fire at pleasure, yet it is

entirely unsuitable for a large building, or for rooms where many persons are assembled, and have fixed seats, similar to a school, lecture-room, factory, &c.

A stove in a room heats both by direct radiation and by heating the air that comes in immediate contact with it.

But our latest styles of elegant new patent gas-consuming air-tight stoves, require so small an amount of air to support combustion, that there is a strong probability of the occupants of a room thus heated smothering to death for want of fresh air, sooner or later, and generally the former.

A stove, if properly used, makes one of the most healthy and economical means of heating now known. There should always be a separate pipe for introducing the fresh air from the external atmosphere, which fresh and cold air should be discharged on or near the top of the stove. And if this supply of fresh air is abundant, with a constant evaporation of moisture sufficient to compensate for the increased capacity therefore due to the additional heat given it, and an opening into a heated flue near the ceiling, to be opened in the evening when the gas-lights are burning, or when the room is too hot, and kept shut at all other times, with another opening into a heated flue on a level with the floor, which should be kept *always open* to carry off the cold, heavy foul air from the floor—a stove thus arranged for many small isolated rooms, makes one of the most economical as well as most comfortable and healthy means of heating at our command. It combines the three great essentials necessary for comfort and health—*warmth*, partially by direct radiation, *fresh air* and *moisture*. But neither the open fire nor the stove, as desirable as they may be in many small rooms, are suitable for large rooms, especially where many persons are assembled. Heating principally by circulating warmed air, or in combination with direct radiation from exposed pipes filled with steam or hot water, is in such cases more convenient.

(To be continued.)

From the London Engineering, No 64.

HOW TO TAKE AWAY SHAKE IN SCREW STEAMERS.

We all know that screw steamers usually shake very much at the stern, and all this shaking cannot be accomplished without a waste of power, while it greatly impairs the comfort of passengers in the

ship. It will be useful to state, therefore, what the cause of this shake is, and how it may be remedied.

In the dynamometer applied to the *Rattler*, at the first introduction of the screw-propeller, it was found that each time the two-bladed screw came in the line of the stern-post, the thrust was momentarily increased, from the circumstance of the dead water in the rear of the stern-post, into which the screw then came, moving with nearly the same velocity as the ship, and the screw consequently for the moment acted upon it with nearly its whole velocity of rotation instead of the difference in the velocity of the screw and ship. Now, although in modern ships the stern-post is made too thin to drag much dead water after it, the skin of the ship drags a film after it, which the screw encounters at a certain part of its rotation, and action analogous to that which took place in the *Rattler* is thus induced. The main cause of the shaking at the stern is the inadequate size of the orifice in the dead wood in which the screw revolves. The screw, in revolving, carries a thick coating of water with it; and if the hole is only sufficiently large to allow the screw itself to revolve without this coating, it will follow that at each revolution the coating of water will be clipped over at the same time that this water strikes violently the sides of the dead wood and shakes the ship. One palliative is to enlarge the hole; another is to use a split screw, or two narrow screws, placed one immediately behind the other on the shaft, as in Mangin's arrangement; and the last and best is to carry the shaft through the rudder, and to allow the screw to revolve clear of everything, and astern of everything, at the extreme end of the ship. The rudder must, in such case, work in a frame, a boss in which will receive the end of the screw-pipe, and the screw itself will be overhung. The arrangement will be still easier if twin screws be employed; and those screws should be sunk as deeply in the water as possible, as the deeper they are, the less likely they are to be raised out of the water, and the less slip there will be.

GROUND BATTERIES.*

By Mr. A. G. Ballantyne, Electrician.

To the Members of the Franklin Institute.

Gentlemen: The subject that I have the honor of submitting for your consideration this evening, I think, is one of very considerable importance at the present stage of scientific research. Amongst

---

* Abstract of paper read before the Franklin Institute, at the Stated Meeting, March 20th, 1867.

the various branches of the natural sciences, I have no doubt you will readily agree with me, that none has advanced so rapidly as that connected with electricity, that powerful and sublime agent which we perceive so impressively in the lightning and the thunder—that subtle and highly rarified element that pervades every atom of matter throughout our globe, and, in the twinkling of an eye, can send our thoughts to the utmost ends of the earth—deserves high appreciation, and untiring energy for its investigation.

The many appliances to which the electric fluid has already been adapted, (some of the highest importance to civilization and the general welfare of the human race,) show plainly how much has been done, while much more is yet to be done before we can arrive at the limits of its usefulness and power. Instruments have been contrived for diverting it from its latent condition, and other instruments, of very delicate workmanship, have been so constructed for detecting its presence when disturbed, that we are able to use it in many of the arts. As a motive power, it has been made to sustain, and even propel, many tons in weight. As an illuminating power, no artificial light ever yet discovered can equal it for brilliancy. As a chemical agent, nothing else in the laboratory can decompose an electrolyte, or, in other words, perform the various operations of analysis and synthesis so effectually as an uniform current of electricity.

For these different purposes, then, it is desirable that this fluid, or power, or principle, should be obtained with as little trouble and expense as possible, and to this particular end philosophers have directed their attention for many years. Professors of electrical science have propounded theories, and practical men have carried them out, as far as possible, in the construction of galvanic batteries, but, in my opinion, both have clung with too much tenacity to the original voltaic "*pile and crown of cups,*" invented many years ago by Volta, the Italian philosopher, whose name they bear, and up to the present day we have scarcely been able to get over the copper and the zinc excited by acid or saline solutions. Nor do I think we will ever get over the many difficulties with which we have to contend until we throw open wide the portals of that extensive storehouse—*the earth*, for an unlimited supply of electricity. As the first step in this direction, I beg to lay before you my experience in the construction of ground batteries, for generating a permanent current of galvanic electricity, uniform in its action, and of very considerable power, especially for any purpose where quantity is required, such as elec-

troplating or other decomposing operations. In every current of electricity, by whatever means it is produced, there are two peculiarities—quantity and intensity. These properties have been very ably discussed by Professor Morton in one of his lectures last winter, so that simply referring to the facts, that quantity is the actual amount of fluid produced, and intensity is the force with which that amount is passed through conductors, will be sufficient for my present purpose.

In 1846 I was in the employment of Mr. Alexander Bain, of Edinburgh, in Scotland, and superintended the laying of his one-wire telegraph from that city to Glasgow, a distance of forty-eight miles. The principle of this telegraph was, that the earth acted as one of the conductors, and the single wire, insulated on the tops of poles, as the other conductor, the termini of this wire being connected to metallic plates, sunk two or three feet into the ground, forming a complete circuit. While we were investigating the best method of connecting the ends of this long single wire with the earth, we found that various substances, excited by the moisture of the earth, not only acted as simple conductors, but generated a current of their own, contending slightly against a Smee's Battery we had in the arrangement for acting on the instruments, so that ultimately, to avoid this, we put a metallic plate, of the same kind, to each end of the wire.

Two or three years after this time, I had constructed a mechanical toy, in the form of an old man pumping water, to be worked by electro-magnetism, but one difficulty I had to keep the old man constantly moving, was a permanent battery. I thought of our experiments with the telegraph, and sunk a plate of zinc and a plate of copper, about two feet square, into a deep hole in the yard, and placed about eight inches apart, the space between being filled up with damp earth, and covered over with pavement, as before, two wires insulated with cord steeped in tar being brought from the plates into the house. This arrangement kept the little figure moving for more than three years, indeed until we were leaving the house. At this time I was anxious to know the condition of the plates, and on removing them I found the zinc quite clean, and very little changed, but the copper was much corroded, and so brittle that I did not take the trouble of lifting it all up.

The effects produced by the above observations led on to renewed efforts to obtain a permanent current of greater power. For this purpose I placed a basket of common coke (obtained at a gas works)

into a pond of water, with a plate of zinc in close proximity; a thick copper wire, No. 14, tied round a piece of the coke, and another piece of the same size soldered to the zinc. This arrangement acted with considerable power upon an electro-magnet, and with great uniformity for several months. This last experiment terminated in such a way that led to the final and most efficient method of constructing a permanent ground battery. The pond where the zinc and coke was deposited dried up during the summer, and left one-third of the two elements quite dry and exposed to the action of the atmosphere, while the other two-thirds of their surface remained buried in soft mud. I thought now that every trace of galvanic action must have ceased, but, to my astonishment, very little diminution of power had taken place. The apparatus I had for testing its power was a small electro-magnet, with its keeper fixed to the end of a lever, such as they use for weighing machines. By this simple arrangement the slightest difference of power can be detected.

The most complete form of this battery for permanency and uniformity of action, I will now explain in the following manner: A hole about four or five feet deep may be sunk in the ground, either in a cellar or out of doors, and about six feet in diameter. Then a sheet of zinc, about ten feet long and two feet eight inches wide, is to be bent round in the form of a tub without a bottom, and placed in this hole, about one foot from the sides. It will require, also, five or six bushels of coke to fill up the spaces outside and inside of the circular sheet of zinc. The process of packing may now be proceeded with. This operation requires the greatest care, so that no part of the zinc and coke can possibly come into contact with each other. The inside of the zinc cylinder is to be completely filled with coke, with a lair or stratum of damp earth placed between, about two inches in thickness. The same process is also to be performed outside of the zinc cylinder, using the same caution not to allow the smallest particle of carbon to come in contact with the zinc. This operation must be performed either with the hand or a small trowel. Two long thick copper wires, about No. 14, is now to be connected with these elements; the ends of the wires must be well tinned with a soldering bolt, about six or eight inches from the joining to the coke and zinc. The best method of connecting the wire to the coke is, to take one of the largest pieces of the coke, and insert the point of the tinned wire into one of its crevices, and then pour a little melted lead, from a ladle, very slowly round the end of the wire. By doing this, the lead will make metallic

contact with the tinned wire, and also run into every little interstice of the coke and completely cement it to it. A piece of coke prepared in this way is to be placed amongst the coke, on each side of the zinc, and connected together a little way from it; the wire making contact with the zinc may be soldered in the ordinary way. The two long wires must be perfectly insulated from their places of contact with the zinc and coke, both from each other and from the moisture of the surrounding earth. There are several ways of doing this, all equally efficient, but the one I adopted I consider the simplest, least expensive, and quite as successful as any of the other methods.

Take two copper wires, long enough to reach to your laboratory, or other place or places of operation. Insulate with cotton, then coat them over separately with black Japan varnish, such as photographers use for backing their positive glass pictures. When this coating has become firm, which will require about half an hour, twist the wires together their whole length, not very closely, but sufficient to keep them from separating; then give them another coating with the varnish, and when that has hardened, another coating; when, for greater security, a third may be applied. The conductors are now fit to be carried to any part of a building, always using pieces of leather or canvas where nails have to be used over walls or fences.

If this line of wires is required to be put in any public place where danger might be apprehended, it would be advisable to put it through a length or two of iron gas-pipe, high enough to be out of the reach of any person who might injure it, by accident or otherwise. We will suppose now we have reached the apartment where this battery is to be used,—nothing more has to be done but fix the ends of the wires to two binding screws, made fast in some convenient place, where two short wires may at any time be connected to them. Branches may be carried in this manner to every room in a building, from the main wires, but only one pair can be used at the same time. The amount of electricity evolved by the apparatus just described is never less in intensity and much greater in quantity than one pint cell of Daniell's arrangement in good action, and very often greater than two pint cells, which is quite sufficient for the majority of purposes to which galvanic electricity is applied. If a much weaker current is required than this arrangement evolves, its progress can be impeded by using iron or platinum wire, of the desired thickness, in connection with the terminal screws.

In conclusion, I would beg a few moments to make some remarks

upon the advantages of this battery for many purposes. The whole subject of electrical science is much simpler and less complicated than many people suppose, and all we have to get thoroughly acquainted with is, that there are but *two currents* that have ever been detected in any electrical, magnetic or galvanic series, and that these two currents have but two properties—*quantity* and *intensity*. These two currents have had various names given to them, such as positive and negative, anode and cathode, zincode and platinode, &c. Positive and negative are not very appropriate terms, as we have a current each way; anode and cathode, meaning the upward and downward way, is somewhat nearer; zincode and platinode has reference only to those two metals, and consequently not so good. The words *greater* and *less* would express their character more truthfully than either of the above—or, to make the terms more euphonious, we might say *major* and *minor* currents.

However, names are but secondary matters, so long as we understand what they mean.

The quantity and intensity of these two currents produce such a variety of effects upon different elements, that the student often mistakes their true character, and represents them as a variety of currents, whereas it is, in reality, different degrees of intensity of the same current. In the construction of some of those electro-magnetic machines for medical purposes, it is stated, they can give out six different currents. Now, from the nature and character of the electric fluid, it is simply an impossibility. Certainly, a machine may be constructed so as, from from the primary coil, a current is induced into the secondary coil, and from the secondary a gain into a third, and so on *ad infinitum;* but what does all this mean? It is only a different method of increasing the induced magnetic intensity. All this can be done by one secondary coil of greater length. Indeed, the tension of an induced magnetic current may be increased until it becomes identical with statical or frictional electricity. This statement is amply proved by the Ruhmkorff coil.

It has been stated by medical electricians, of the highest standing and undoubted authority, that a quantitative current passed through a primary coil, with just as much magnetic intensity as will pass it freely through the body, is the best form of application in disease. For this purpose, then, the Ground Battery is pre-eminently the best, on account of the extent of surface exposed and the quantity generated. Intensity can be increased in many ways, but quantity re-

quires exposure of a large surface with little excitement. This same rule holds good in the deposition of metals and all other decomposing operations. I have known one of those batteries depositing copper upon six vessels at the same time. There was a great demand for glass retorts, coated with copper, about ten years ago, in England, amongst manufacturing and experimental chemists. Many of those vessels were prepared by Messrs. Edwards & Wharrie, of Liverpool, by the electrotype process. They first coated over the glass vessel with tin-foil, in the same manner as a Leyden jar, on the outside; then immersed it in a solution of sulphate of copper in connection with a ground battery. This was the best one of the kind I had seen, and the last time I heard of it, it had been six years in operation, and was then quite as good as when first put into the ground. One feature I might mention here about this battery that I cannot account for very clearly—that is, that it improves in action, nearly one-half, for two or three weeks after it is put into the earth, and then remains quite steady and uniform. Time has not given me an opportunity of testing the durability of these batteries, but I have never known one of them to stop acting, except one, and there were very good reasons for that. A gentleman of my acquaintance put one into the earth, and when it was filled up deluged the whole place with several bucketsful of a strong solution of salt in water. The result was a very powerful action at first, but gradually diminished, till, at the end of five or six months, a galvanometer could scarcely detect the slightest trace. Nothing but the moisture of the earth itself must be used, and good effects will be the consequence.

Those who are interested in the progress of galvanic science, and have the means and opportunity of investigating this subject, would some day confer a lasting obligation upon the world in supplying a *motive power*, an *illuminating power*, and a *decomposing power*, at a mere nominal expense, and superior to anything ever yet invented or discovered.

The above remarks are from my own observation and experience, so that I can guarantee their truthfulness, and with much pleasure hand them over to the members of the Franklin Institute, if thought worthy of their acceptance.

From the London Engineering, No. 64.

BLACKWALL ROCK AND ITS LESSONS.

There is a part of the river Thames, immediately above Blackwall Stairs, and below the entrance to the West India Docks, where an eddy of the stream accumulates a shoal through which some agglutinating springs rise that convert the sand into rock, which has occasionally to be blasted. In 1838, when the vessels of the Peninsular Steam Company sailed from Blackwall, this rock attracted Mr. Bourne's attention, as it incommoded the vessels with which he was then concerned; and having observed the nature of the phenomenon, he saw that it might be artificially imitated with advantage in certain difficult engineering works, and he treasured up the recollection in his memory for future guidance.

In 1847, Mr. Bourne went to India with Sir Macdonald Stephenson, as one of the engineers of the East India Railway, and among the works which had to be constructed was a bridge over the river Soane, in length nearly equal to the Blackwall Railway, and with a foundation of quicksand as deep as borings had extended. Here it appeared to Mr. Bourne was a case for the application of the lesson he had learned from Blackwall, and he at once proposed to surmount the difficulty of foundations by converting the quicksand into rock to such an extent as would give the necessary stability to the superstructure. A hill of iron pyrites lay near at hand, and Mr. Bourne proposed to sink perforated pipes into the quicksand, and to inject into it through them a sufficient quantity of iron water to stick together the whole mass. Here would be an artificial production of rock, imitating its natural production at Blackwall.

In 1848, the progress of the East India Railway was arrested by financial difficulties, and when the work was eventually resumed, the direction of the line was altered so as to proceed up the valley of the Ganges, instead of adopting the line of the trunk-road, as the Government commission had recommended. The Soane, consequently, was not crossed eventually at the place originally proposed, but much lower down, and the foundations were obtained by sinking wells in the way usually adopted in Indian works. As executed, the Soane Bridge is the longest bridge in the world, that of the St. Lawrence alone excepted, and it has been constructed by Mr. Turnbull in a most efficient and successful manner, and constitutes a great monument of his engineering ability. But the difficulties of the work would have been lessened and its cost reduced if the foundations had been laid upon artificial rock, as Mr. Bourne had some years before proposed. We have no doubt that this resource will hereafter become a valuable feature in engineering, as it enables us to reduce enormously the cost and difficulty of constructing secure foundations in treacherous ground.

COUNTERBALANCING RECIPROCATING ENGINES.

By Fred. J. Slade, Civil Engineer.

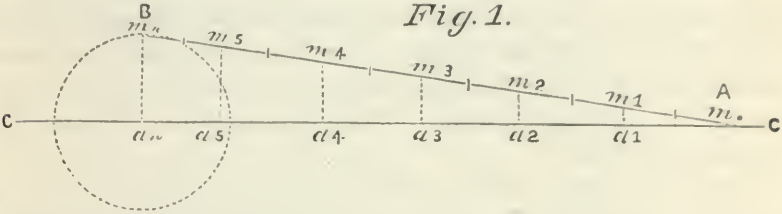
The perfect counterbalancing of the momentum of the reciprocating parts of an engine in an *horizontal direction*, is often a matter of considerable importance, especially when the engine is required to work at a high speed. It is seldom, however, that this is successfully carried out, except in horizontal engines, from the fact that the manner in which it can be accomplished is not at first sight apparent. We propose, in the present article, to give a complete discussion of the elements involved in this problem, and to deduce a simple and direct method by which the horizontal momentum of any engine, inclined or vertical, as well as horizontal, may be properly counterbalanced. We have intimated already, that it is only with reference to an horizontal direction that the subject is to be considered, since, in general, it is supposed that an engine is so firmly secured as not to be influenced by a force acting in a vertical direction, while it is to prevent all tendency to horizontal swaying that the counterbalance is applied.

Let us, in the first place, consider what it is that causes this tendency to motion in the direction of the centre line in an unbalanced engine. Disregarding, for the present, the effect of the connecting rod, we have the fact, that when the crank is at right angles with the centre line, the reciprocating parts are in motion with a maximum velocity. If uncontrolled by the crank-pin, they would, of course, continue to move forward in a straight line at the same velocity, and would oppose a resistance to any body tending to arrest their motion. Such a body is the crank-pin, and accordingly, during the last half of the stroke, a pressure is exerted upon that part, the amount of which will depend on the mass and velocity of the reciprocating parts. Having brought the parts to rest, it is now necessary to set them in motion again in the opposite direction, and to do this will require exactly as much work as was absorbed in arresting their progress before. If, for simplicity's sake, we regard the crank-pin as the motor, which we may do without changing in the least any of the facts involved, we see that the pressure on that point while bringing the parts to rest, and that while starting them into motion, is continually in the same direction, so that we have, during the whole of the

half revolution of the crank, from its position at right angles to the centre line, on one side, to the same position on the other side, a pressure exerted in the direction of the end of the stroke which lies in that half revolution. The same is, of course, equally true of both half revolutions of the crank from the dividing line at right angles to the centre line. The point which we wish to call attention to is, that it is not the velocity, but the *change of velocity*, that gives rise to pressure, and which, therefore, needs to be counteracted. In the case of an engine in which the power is taken off from the shaft on the other side of the pillar-block from the crank, as is almost universally the case, whatever pressure is applied to the crank-pin is transmitted directly to the pillow-block, and hence the effect of this alternating force arising from the changes in volocity of the reciprocating parts, in producing a bodily motion of the whole engine. Now, to prevent this in an horizontal engine, we place a weight equal in magnitude to that of the reciprocating parts opposite to the crank-pin, and at an equal distance from the centre of the shaft; so that the changes produced in its velocity *horizontally*, may at all times be equal to those occurring in the reciprocating parts, and therefore exactly neutralize their effect. As, however, this mass moves in a circle, it exerts a pressure at right angles to the centre line at all points in its revolution, except when it coincides with that line; but as in this case this is a vertical force, we do not regard it. We resolve the centrifugal force of the revolving weight into its two components, at right angles to and parallel with the centre line in this manner, because this gives us at once a key to all the effects produced by the counterbalance weight. The component parallel with the centre line is exactly neutralized in its effects on the stability of the engine by the action of the reciprocating parts; the other remains unaffected. We see already, therefore, that this method of counterbalancing would not answer for an inclined or vertical engine, since this latter force would in these cases have a direction approximating to the horizontal, and would therefore give rise to a motion exactly such as we wish to prevent. But before proceeding to examine these cases, let us investigate the peculiar motion of the connecting-rod, partaking as it does of both a reciprocating and a rotary motion, and see how this is to be provided for. It is evident that the end immediately at the crank-pin, will offer a resistance to any force or body which tends to vary its velocity in the direction at right angles to the centre line, in exactly the same manner as a body re-

volving with the crank, or say the crank-pin itself, and this will, of course, in all directions of the centre line, horizontal or vertical, be perfectly counterbalanced by a weight placed opposite to it. Our first problem, then, is to ascertain what proportion of the weight of the rod is to be so allowed for. If we let A B, Fig. 1, represent the connecting-rod, supposing it also stripped of all extra weight at either end, and considered merely as a plain bar, we may suppose it to be

Fig. 1.



divided into any number of small or elementary masses, of equal magnitude, m, m, &c. It is evident that the velocity of each of these, when the rod coincides with the centre line, is proportional to its distance from the centre, A, and the amount of work stored up in each, being as the square of the velocity, will be represented by $\frac{1}{2} m_0 \times 0$, $m_1 a_1^2$, $m_2 a_2^2$, &c. Now, in moving to the position, A B, in which they are at rest, in this direction each point passes through a distance proportioned to its distance from the centre, and consequently the resistance which it offers during this motion to the force tending to bring it to rest, will be represented by $\frac{m_m a_m^2}{a^m} = m_m a_m$, or, in other words, the pressure which it exerts will be proportional to the distance from the centre, A. These pressures are all sustained by the crank-pin at one end, and the slides at the other, and the proportion of each, which either of these bears, is in the inverse ratio of the distance of the moving masses from the sustaining point, or in the direct ratio of its distance from the opposite end of the rod. The pressure coming on the crank-pin, therefore, will be represented by $\frac{1}{2} m_0 \times 0 + m_1 a_1^2 + m_2 a_2^2 + \cdots + \frac{1}{2} m_n a_n^2$, or, as the sum of all the elementary masses into the squares of their distances from the point, A. Calling the distance, A B, unity, and the sum of all the masses $\frac{1}{2} m_0$, m_1, &c., M, we shall have the sum of this series equal to $\frac{1}{3}$ M. From this, we find that the pressure on the crank-pin in a direction at right angles to the centre line, resulting from the swing of a connecting-rod of uniform dimensions, would be the same as that of a mass of one-third the

weight of the rod situated at the crank-pin; and if we add to this the weight of the extra metal in the end of the rod at the crank-pin, we shall have the amount of weight which will be necessary to counterbalance this motion of the connecting-rod, supposing it to be placed diametrically opposite the crank, and at the same distance from the centre of the shaft.

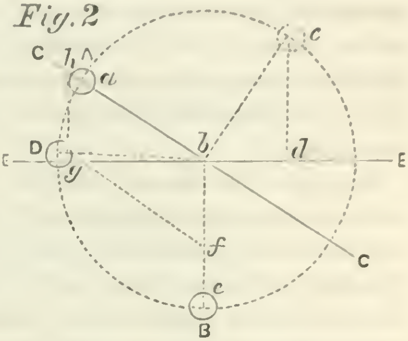
We have observed that a part of the pressure thus generated in the connecting-rod comes upon the slides. The portion of the pressure exerted by each of the elementary masses, m, so sustained, being proportional to its distance from the end, B, while the total amount of each such pressure is proportional to its distance from A, we shall have for the combined pressure of all the masses, m, the sum of a series of the form,

$\frac{1}{2} mnp \times 0 + m(n-1) p \frac{1}{n} + m(n-2) p \frac{2}{n} + \dots \frac{1}{2} m(n-n) p \frac{n}{n}$, in which $p =$ the resistance offered by an elementary mass, m, moving at a unit's distance from the centre, A, n, such units making up the length of the rod. The sum of this series we find to be $\frac{1}{6}$ M, or the pressure on the slides due to the changing momentum of the connecting-rod will be equal to that which would be exerted on the crank, by a weight of one-sixth the magnitude of the plain part of the rod revolving with the velocity of the crank-pin. It is not necessary, in this case, to make any addition for the extra weight of the ends of the rod, since at both these points the mass is inoperative to produce pressure on the slides, as is shown from the fact that the extreme terms of our series are both equal to zero.

It is not possible to balance this part of the momentum of the connecting-rod by a weight applied to the shaft, since the opposing force so produced would not act in the same line with that which it would be required to counteract. It is, however, of little importance that we should do so, since, in comparison with the pressure coming on the same part from the force of the steam exerted through the inclined rod, it is insignificant, and it is noticed here merely for the purpose of bringing all the acting forces before our minds. We have now found, then, that a weight equal to one-third the body of the connecting-rod (if it be one of uniform dimensions) and the whole of the extra weight at the crank-pin, must be placed diametrically opposite to the crank-pin, and at an equal distance from the centre of the shaft, whatever be the inclination of the engine. This being done, we will proceed to inquire what will be the position and magnitude of the mass required to counterbalance the directly reciprocating

parts, and the remaining two-thirds of the connecting-rod. Let C C, Fig. 2, represent the direction of the centre line of the engine making any angle, C b E, with the horizontal, and A a mass equal to the weight of these parts, and exactly sufficient, therefore, if placed opposite to the crank-pin, to counterbalance their momentum *in the direction c c.* Let us represent the weight of this mass by the length of the radius ab. Now, the effect of the centrifugal force of the mass, A, placed as we have supposed, will be at all times neutralized in the direction parallel with the line C C by the motion of the reciprocating parts, but will, as we have already observed, exert an influence in a direction at right angles to that line, varying in amount according to the position of A, its intensity being proportional to the sine of the angle by which A is removed from the centre line. Its maximum effect, therefore, will be, when this angle is 90°, or when the weight is at c. We may resolve this force into two components, $b\ d$ and $c\ d$, the one horizontal and the other vertical, and equal respectively to the sine and cosine of the angle which the centre line of the engine makes with the horizontal, and we now wish to neutralize this horizontal component.

Fig. 2



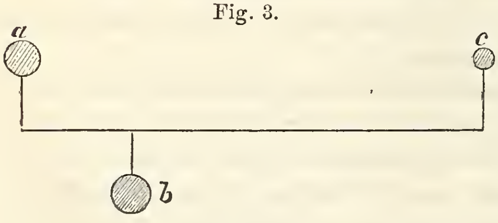
Draw the radius $b\ e$ in a vertical direction when the mass A is on the centre line. Now, if we place at the extremity of this radius a mass, B, equal to bd, we shall have no horizontal effect produced by it when A is on the centre line, but when A is at right angles to that line, B will be in an horizontal direction from the centre of the shaft, and will accordingly exert a force directly opposed and exactly equal to the horizontal component, $b\ d$, of the centrifugal force of A, and we should accordingly have the momentum of all the parts perfectly counterbalanced in that direction.

It now remains to combine the three weights which we have successively found necessary, and to find the position and magnitude of a single mass that shall exactly perform the duty of the three. To do this, lay off on the centre line the distance, $b\ h$, equal to the combined weight of A and the mass that we first found for counterbalancing the swing of the connecting-rod ; on $b\ c$ lay off a distance, $b\ f$,

equal to the mass, B, and complete the parallelogram, *b f g h*. The diagonal, *b g*, will represent the direction and magnitude of the resulting weight. Were it not for the effect of the weight necessary to counteract the change of momentum of the connecting-rod at right angles to the centre line, the position of this final weight would always be in an horizontal direction from the shaft when the engine was on centre, since the line, *h g*, equal to the sine of the angle of inclination, would then fall from the point, *a*, situated on the circle; as it is, the required direction will always be somewhat nearer to the centre line.

We have thus far supposed the counterweight to act in the same plane in which the reciprocating parts move. But as the weight itself cannot be placed exactly in that plane, we must see how we can dispose it so as to produce the same effect as if so placed. If it is a crank-shaft engine, we can easily accomplish this by dividing the counterweight into two equal parts, and placing one on each side of the crank, equidistant along the shaft from the centre line of the engine; or if, for particular reasons, this is not practicable, then we must divide the weight into portions inversely proportional to the distance from the centre line, at which we are obliged to locate them. In the case of an overhung crank, we must proceed in a different yet similar manner. It will be necessary, in order to avoid the tendency to produce rotation that exists in the case of *two* opposite forces not acting in the same line, to provide a third force, and this we may do by placing a weight exactly opposed in direction to the counterweight, on the opposite side of the latter, from the centre line of the engine, and of a magnitude, as compared with that which we have already assigned to the counterweight, inversely as the ratio which its distance from the position of the counterweight bears to that of the counterweight from the centre line measuring along the shaft, and the counterbalance weight must now be augmented by an amount equal to this second weight. The case of a double cylinder engine differs in no respect from those which we have already considered, since each set of reciprocating parts is to be balanced separately, and the weights may then be combined in the manner already illustrated.

Fig. 3.



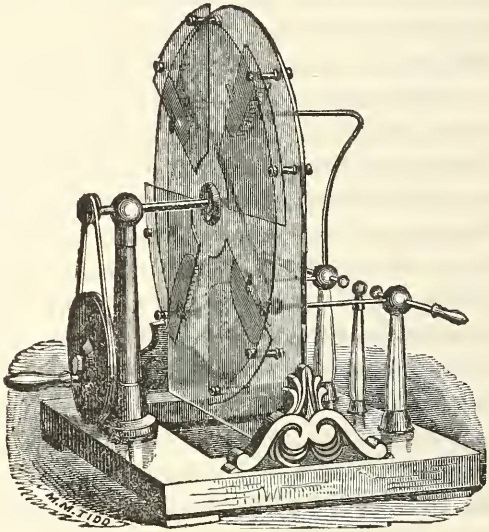
This, then, is the proper manner in which to counterweight an engine of any description, horizontal, inclined or vertical. In the former case, the weight, supposing it situated in the plane of the centre line, would fall opposite to the crank, and be equal in magnitude to the total weight of the reciprocating parts; in the latter it would be placed in the same position, but would only be equal to one-third the connecting-rod, as already determined.

There remains yet one fact to be noticed in connection with this subject, viz: the effect of the connecting-rod in producing more rapid motion of the reciprocating parts when they are in the portion of their stroke farthest from the crank-shaft, than when in that nearest to it. With a rod six times the length of the crank, the maximum velocity is absorbed and re-imparted in the former portion of the revolution, while the crank advances in the direction of the centre line through but five-sevenths the space through which it moves in the latter case, while the rate of motion when the crank is near the centre line is about forty per cent. greater on the one end than on the other. As the same amount of *vis viva*, therefore, has to be absorbed and imparted by a less forward motion of the crank-pin, the pressure coming upon that point must be greater in the same proportion at one end and less at the other. The result of this is, that if the engine were balanced for the mean speed of the piston, the counterbalance weight would be too little when the piston was at the end of its stroke from the shaft, and too much when at the other end. In both cases, therefore, there would be a force acting to urge the engine bodily in the direction away from the shaft. But this pressure being always in one direction, would not give rise to vibration, except, perhaps, to a very limited extent, as its intensity varied at different portions of the stroke. It is evident that any increase or diminution of the counterbalance weight, would only tend to produce inequality in the effect of this force on the two strokes. The writer lately witnessed a beautiful illustration of the fact now referred to, in the working of a high speed engine that was placed for trial on some planed iron surfaces, and not bolted down. After it had been running a few minutes, he observed that it had moved bodily backward several inches, and the present explanation thereupon suggested itself to him as the cause of the phenomenon.

359 Oxford Road, Manchester, England.

RITCHIE'S MODIFICATION OF THE HOLTZ MACHINE.

The accompanying cut shows the arrangement of the Holtz Electrical Machine, devised by E. S. Ritchie, of Boston.



A strong plate of plate-glass is fixed in a vertical position upon a mahogany frame, and sustains the bearing of one end of the revolving shaft supported at its opposite end by a single pillar.

The revolving thin plate is fixed in the usual manner upon its shaft, by a collar and binding nut of vulcanite, and is placed about one inch distant from the thick plate.

Four holes are drilled through the thick plate at suitable distances from the centre, through which pass the stems of the rods with points or *combs;* balls of metal or vulcanite screw against the opposite side and hold the combs firmly in place. These balls are connected with the discharging pillars.

Four pairs of little pillars, or bolts, project from the supporting plate, in a circle surrounding the revolving plate, made of vulcanite. Their outer ends are furnished with movable screw shoulders and nuts. Upon each pair is placed one of the glass sectors of the "Holtz" machine; or, on alternate pairs, the rubber sectors of the "Bertsch" arrangement.

These pillars, (the middle one removable at pleasure,) with sliding

discharging rods, furnished with balls of different diameters and points, are connected by wires (covered by insulating material if desirable) to the balls of the combs. Any desired combination can easily be made. Either of the sectors or combs, with its connections can at pleasure be removed, or their distance to the revolving plate adjusted. The relative positions of the parts are held with great firmness.

The presence of the stationary plate, near the revolving one, adds to its insulation, and in this way to the efficiency of the machine. In other respects, the advantages sought are simplicity of construction and stability of the parts. The insulation of the supporting plate, allows the discharges to be brought nearer the revolving plate, and avoids disturbing influences from one to the other, and allows the machine to be much more compact in form.

We take upon ourselves the responsibility of publishing the following letter which Mr. Ritchie has sent us with permission to use; but with the expression of doubts as to the wisdom of making it public, because of the many anamolies in this machine, and the interruption of his experiments, by reason of which they have been less numerous and extended than he could have wished. We regard the results reached, however, as so interesting, and the field so full of promise to all who may be led to cultivate it, that a little risk may well be run of having to modify some deduction in future. Mr. Ritchie's reputation in matters of electrical science, is, moreover, such as to enable him to correct himself with good grace, should any of his present conclusions require modification in future.

Prof. Morton.

DEAR SIR: It is with some hesitation, that I send you the result of some experiments, made with view of determining the electrical condition of the different portions of the revolving plate of the Holtz machine; but which experiments were interrupted before I had verified the results as I wish to do.

I removed the two upper sectors of my machine, leaving two at 90° apart, thus leaving nearly three-fourths of the plate between the sectors on one side. From this portion I removed every conductor as far as possible; still, the machine, in action, is surrounded by *such an atmosphere* of electricity, that there is danger of being deceived in the results sought.

I took proof planes of two and three inches diameter, with lac handles, to take the charge and bring to the gold leaf electrometer, stopping the plate suddenly, and applying the proof planes—sometimes to both sides and sometimes on one side, simultaneously, or alternately. They *in general,* indicated opposite electricities and different intensity

in opposite sides of the plate; yet, in a large number of trials, made as nearly as possible in the same place relatively to the sectors, the results were so contradictory that nothing could be determined,—sometimes the one side was positive, sometimes negative.

I then applied the proof plane on one side and a disc of metal of larger diameter to the opposite side in connection with the earth, thus leaving the electricity on the side of the proof plane free, and by repeating many times the experiment in the same place, on both sides, I was surprised to find both sides of the revolving plate of the same kind in all cases; *negative* when the preceding sector had been excited *positive*.

The two sides of the sectors, when removed, show also the same kind.

The role of the papers upon the sectors is far from clear; they may be on either or both sides of the glass. On a number, made as nearly alike as possible, a few may act well; the varnish of some may be scratched even through the paper in all directions, and with slight loss of effect. Others may resist all excitation, but, by doubling a piece of tin-foil over the edge, may perform well.

The paper may be left off entirely, and a piece of tin-foil doubled over the edge, as large on each side as the paper is usually made, retaining a card-point *feeder*, without varnish, and yet this may do very well for at least one of the sectors where only a pair is used.

The power of the instrument for evolving ozone is very great, and I have reason to caution those using the machine in a confused atmosphere.

Very respectfully, yours,

E. S. Ritchie.

From the London Mechanics' Magazine, January, 1867.

(Continued from page 263.)

ON SOUNDING AND SENSITIVE FLAMES.

By Professor Tyndall.

Another flame is now before you. It issues from a burner, formed of ordinary gas-tubing by my assistant. The flame is 18 inches long, and smokes copiously. I sound the whistle; the flame falls to a height of 9 inches, the smoke disappears, and the brilliancy of the flame is augmented. Here are two other flames, also issuing from burners formed by my assistant. The one of them is long, straight, and smoky; the other is short, forked, and brilliant. I sound the whistle; the long flame becomes short, forked, and brilliant; the forked flame becomes long and smoky. As regards, therefore, their response to the sonorous waves, the one of these flames is the exact

complement of the other. Here are various flat flames, 10 inches high, and about 3 inches across at their widest part. They are purposely made forked flames. When the whistle sounds, the plane of each flame turns ninety degrees round, and continues in its new position as long as the whistle continues to sound.

Here, again, is a flame of admirable steadiness and brilliancy, issuing from a single circular orifice in a common iron nipple. I whistle, clap my hand, strike the anvil, and produce other sounds, the flame is perfectly steady. Observe the gradual change from this apathy to sensitiveness. The flame is now 4 inches high. I make its height 6 inches; it is still indifferent. I make it 10 inches, a barely perceptible quiver responds to the whistle. I make it 14 inches high, and now it jumps briskly the moment the anvil is tapped or the whistle sounded. I augment the pressure, the flame is now 16 inches long, and you observe a quivering which announces that the flame is near roaring; I increase the pressure; it now roars, and shortens at the same time to a height of 8 inches. I diminish the pressure a little; the flame is again 16 inches long, but it is on the point of roaring. It stands as it were on the brink of a precipice. *The whistle pushes it over.* Observe it shortens when the whistle sounds, exactly as it did when the pressure was in excess. The sonorous pulses, in fact, furnish the supplement of energy necessary to produce the roar and shorten the flame. This is the simple philosophy of all these sensitive flames.

The pitch of the note chosen to push the flame over the brink is not a matter of indifference. I have here a tuning-fork, which vibrates 256 times in a second, emitting a clear and forcible note. It has no effect upon this flame. Here are three other forks, vibrating respectively 320, 384, and 512 times in a second. Not one of them produces the slightest impression upon the flame. But, besides their fundamental notes, these forks can be caused to sound a series of overnotes of very high pitch. I sound this series of notes: the vibrations are now 1600, 2000, 2400, and 3200 per second respectively. The flame jumps in response to each of these notes; the response to the highest note of the series being the most prompt and energetic of all. To the tap of a hammer upon a board the flame responds; but to the tap of the same hammer upon an anvil the response is much more brisk and animated. The reason is, that the clang of the anvil is rich in the higher tones to which the flame is most sensitive. Here, again, is an inverted bell, which I cause to sound by means of a fiddle-bow, producing a powerful tone. The flame is unmoved. I bring a half-penny into contact with the surface of the bell; the consequent rattle contains the high notes to which the flame is sensitive. It instantly shortens, flutters, and roars when the coin touches the bell.

Here is another flame 20 inches long. I take this fiddle in my hand, and pass a bow over the three strings which emit the deepest notes. There is no response on the part of the flame. I sound the highest string: the jet instantly squats down to a tumultuous bushy

flame, 8 inches long. I have here a small bell, the hammer of which is caused to descend by clockwork. I hold it at a distance of 20 yards from the flame. The strokes follow each other in rhythmic succession, and at every stroke the flame falls from a height of 20 inches to a height of 8 inches.* The rapidity with which sound is propagated through air is well illustrated by these experiments. There is no sensible interval between the stroke of the bell and the shortening of the flame. Some of these flames are of marvellous sensibility; one such is at present burning before you. It is nearly 20 inches long; but the slightest tap on a distant anvil knocks it down to 8 inches. I shake this bunch of keys or these few copper coins in my hand; the flame responds to every tinkle. I may stand at a distance of 20 yards from this flame; the dropping of a sixpence from a height of a couple of inches into a hand already containing coin, knocks the flame down. I cannot walk across the floor without affecting the flame. The creaking of my boots sets it in violent commotion. The crumpling of a bit of paper, or the rustle of a silk dress, does the same. It is startled by the plashing of a raindrop. I speak to the flame, repeating a few lines of poetry; the flame jumps at intervals, apparently picking certain sounds from my utterance to which it can respond, while it is unaffected by others.

In our experiments, downstairs, we have called this the vowel flame, because the different vowel sounds affect it differently. Vowel sounds of the same pitch are known to be readily distinguishable. Their qualities or clang-tints are different, though they have a common fundamental tone. They differ from each other through the admixture of higher tones with the fundamental. It is the presence of these higher tones in different proportions that characterises the vowel sounds, and it is to these same tones, and not to the fundamental one, that our flame is sensitive. I utter a loud and sonorous U, the flame remains steady; I change the sound to O, the flame quivers; I sound E, and now the flame is affected strongly. I utter the words *boot*, *boat* and *beat* in succession. To the first there is no response; to the second, the flame starts; but by the third and fourth it is thrown into violent commotion; the sound *Ah!* is still more powerful. When the vowel sounds are analyzed their constituents are found to vary in accordance with the foregoing experiments; those characterised by the sharpest overtones being the most powerful excitants of the flame.

The flame is peculiarly sensitive to the utterance of the letter S. If the most distant person in the room were to favor me with a "hiss," the flame would be instantly shivered into tumult. The utterance of the word "hush," or "puss," produces the same effect. This hissing sound contains the precise elements that most forcibly affect the flame. The gas issues from its burner with a hiss, and an external

* The bell was carried into the gallery of the theatre, and from that distance produced instantaneously the same effect on the flame.

sound of this character added to that of a gas-jet already on the point of roaring is equivalent to an augmentation of pressure on the issuing stream of gas. I hold in my hand a metal box containing compressed air. I turn the cock for a moment, so as to allow a puff to escape—the flame instantly ducks down, not by any transfer of air from the box to the flame, for I stand at a distance which utterly excludes this idea; it is the *sound* of the issuing air that affects the flame. The hiss produced in one orifice precipitates the tumult at the other.

[We may state for the information of readers who may wish to repeat any of the interesting experiments described by Dr. Tyndall that the one thing necessary to their success is to have the gas delivered with a steady equable pressure. The lecturer made use of a small gasometer, and did not depend on the ordinary service pressure, which is liable to frequent fluctuations.—Ed. M. M.]

THE ZENTMAYER LENS.

In the *Philadelphia Photographer* for May, just received, we find the report of a committee appointed by the Photographic Society, of this city, to make a thorough examination of this lens.

We extract the important results embodied in this report without giving preliminary remarks and general explanations.

"The first experiment was a trial between a 12-inch globe lens, and a Zentmayer of nearly the same focal length.

"In precise terms the Zentmayer lens was 12 inches in focal length, the globe 12·94 inches. The stop used in the globe was $\frac{24}{100}$ths of an inch. That used in the Zentmayer was $\frac{22}{100}$ths of an inch, which were in the following proportions to the focal lengths: Globe, f, 53·92; Zentmayer, 54·54."

"The circles of light," (on the ground glass, Ed.,) "were found by measurement to be 22·8 inches.

"The day was favorable, and an exposure of forty-five seconds was given to each plate. The negatives were equally well exposed.

"In definition and evenness of illumination, there was manifest a decided superiority in the negative by the Zentmayer lens."

(Though it is not mentioned in the report, we know from members of the committee that the focusing and exposure were both conducted with the same stop in the Zentmayer as well as in the globe lens.—Ed.)

"The committee then made pictures with the Zentmayer lens of 18 inches focal length on plates 18 by 24 inches."

The stop here used to expose was $\frac{1}{55}$th of the focal length, a larger one being employed for focusing.

"The result surpassed the expectations of all present. The instrument possesses all the qualifications which constitute excellence in a lens.

"Upon careful examination no difference could be found between the visual and actinic focus."

We have seen many pictures taken with these lenses, and can fully confirm the opinion expressed by the committee that "all the qualifications constituting excellence are possessed by this lens," and that it has a combined extent of angle, flatness of field and depth of focus possessed by no other existing combination.

This lens was first exhibited in public, at the meeting of the Franklin Institute for June, 1866, when it was fully described in the Secretary's report, (see this *Journal*, Vol. LII., page 63.) Our able contemporary, the *British Journal of Photography*, took, with reference to this matter, the strange ground that the lens described must, on theoretical grounds, be inaccurate, especially with reference to want of coincidence in the chemical and luminous foci, and that, therefore, such a lens could not possibly produce the effects stated.

Such *a priori* assertion (we cannot call it reasoning) in opposition to fact, we did not consider it worth while to notice. We could well afford to wait until time and better knowledge should vindicate the truth. Overwhelming testimony at last appears to have convinced our critic that facts could not so easily be disposed of on theoretical grounds. He, however, still tries to force fact into accordance with his theory, and by new assumptions to depreciate the merits of this invention which has the misfortune to operate in opposition to his judgment.

In justice to the inventor we feel called upon to say, that all the new assumptions are as far from the fact as the first one, and that this lens is, beyond doubt, destined to achieve as wide a reputation as the world-renowned American globe lens, (which, as may be noticed in the report above, it excels,) and which, like it, was at first rediculed in the foreign press as an impossibility.

FACTS AND FIGURES IN REGARD TO THE PENNSYLVANIA RAILROAD.

By J. M. Wilson, C.E., Principal Assistant Engineer P. R.R.

We submit to our readers the following interesting statistics furnished through the kindness of Mr. Wilson, from whom we are pro-

mised some other valuable information concerning the new bridges on the same road.

ED.

LENGTH OF MAIN LINE FROM PHILADELPHIA TO PITTSBURGH, INCLUDING HARRISBURG AND LANCASTER RAILROAD *via* MOUNT JOY.

1.—*Track.*

	Miles.	Tenths.
From west end Market Street Bridge to Passenger Station, West Philadelphia	0	2
From Passenger Station, West Philadelphia, to Harrisburg	105	5
From Harrisburg to Passenger Station, Pittsburgh	218	2
From Passenger Station, Pittsburgh, to Duquesne Depot		9
	354	8
Length of road *via* Columbia	358	7
Distance from Passenger Station, West Philadelphia, to Passenger Station, Pittsburgh, *via* Mount Joy—distance travelled, by through passenger trains	353	7
Length of double track, Main line	348	9
Amount of double track yet to be laid, to give continuous double track from Philadelphia to Pittsburgh	5	9
Length of sidings on Main line	121	2

BRANCH ROADS OWNED BY PENNSYLVANIA RAILROAD.

Hollidaysburg Branch	7	6
Indiana "	19	0
Delaware Extension	5	5
Steubenville "	1	2
	33	3

ROADS LEASED BY PENNSYLVANIA RAILROAD.

East Brandywine and Waynesburg	17	0
Harrisburg and Lancaster	54	1
Mifflin and Centre County	6	9
Tyrone and Clearfield	23	5
Bald Eagle Valley	51	2
Ebensburg and Cresson	11	0
Western Pennsylvania Railroad	63	7
Philadelphia and Erie "	287	5
	514	9

AMOUNT OF SINGLE TRACK OPERATED BY PENNSYLVANIA RAILROAD.

Main line	729	3
" sidings	121	2
Branches, including sidings	603	9
Total single track	1554	4

Which, if extended out by shortest present railroad route, would reach from Philadelphia to fifty miles beyond Fort Kearney, N. T., or if laid as one continuous rail, would reach one-eighth around the world.

The road had laid in track January 1st, 1867, over 2000 tons of steel rails, of which some 1500 tons are laid in main tracks, and the balance in sidings. About 250 tons are crucible steel, the balance are Bessemer steel. They are wearing remarkably well. At some points where the above rails have been in use, two or three sets of iron would have worn out, while the steel rails are yet in good condition.

2.—*Tunnels—Main Line.*

There are eight tunnels in Main Line, of the following lengths: 200, 900, 1200, 3612. (Alleghany Mountain,) 650, 300, 450 and 450 feet.

Total lineal feet of tunnelling, 7762 feet.

3.—*Stations on Main Line.*

Passenger	85
Freight	52

4.—*Engine Houses—Main Line.*

West Philadelphia—No. 1	21	engines capacity.
" No. 2	44	"
Columbia	20	"
Harrisburg	44	"
Mifflin	15	"
Altoona	30	"
"	26	"
"	44	"
Conemaugh	15	"
Pittsburgh	44	"
Miscellaneous points on road	11	"
Total	314	"

The Company is now putting up an engine house at Pittsburgh for 40 engines, and contemplates building one at Harrisburg for 44 engines, which will give a total capacity of 396 engines.

5.—*Shops—Main Line.*

There are eight principal shops on Main Line, comprising a total superficial area of buildings of over ten acres actually under roof, exclusive of engine houses and all buildings, except *shops proper.*

6.—*Bridges—Main Line.*

Number of iron bridges, Main Line	141
" wooden " "	18
" stone " " of 21 feet span and upwards,	17
Total length of iron bridges	12,097 feet.
" wooden "	8,595 "

The Company has now under construction and will bring into use this year, 1408 feet lineal of iron bridges. This will alter the above items, giving us

Total length iron bridges	13,505 feet.
" wooden "	7,187 "

7.—*Motive Power, January* 1*st*, 1867, *exclusive of Philadelphia and Erie Railroad.*

Passenger Engines	72
Freight "	230
Switching "	37
Constructing "	23
Total	362

8.—*Passenger and Freight Equipment, Jan.* 1*st*, 1867, *exclusive of Philadelphia and Erie Railroad.*

Passenger Cars	147
Emigrant "	44
Baggage "	43
Mail "	4
Express "	38
Box "	2711
Stock "	995
Gondola "	2072
Coal "	2204
Oil "	50
Total	8308

9.—*Mileage made by Engines during* 1866, *exclusive of Philadelphia and Erie Railroad.*

Passenger Engines	1,775,472
Freight and Switching Engines	5,304,554
Constructing	273,240
Total	7,353,266

It will be noticed particularly, that items 2, 3, 4, 5 and 6 are for *Main line* only, and items 7, 8 and 9 do not include Philadelphia and Erie Railroad. If the engines and cars given in items 7 and 8 were coupled together on one track, they would make a train nearly sixty miles long. The mileage given in item 9 is equivalent to that of one engine running nearly 296 times around the earth.

Educational

(Continued from page 284.)

MAGIC LANTERN

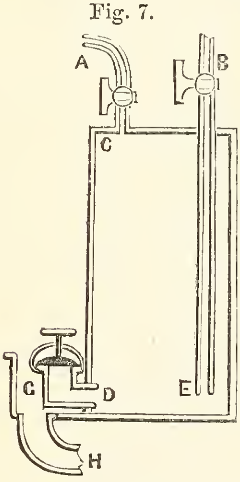
AS A MEANS OF DEMONSTRATION.

Methods of Storing Gas Continued.

Prof. Ogden Doremus, of New York, has for many years employed an arrangement which, as a fixture, has many features of convenience, simplicity and efficiency.

The apparatus is indicated in outline by Fig. 7. In this, C D E represents a large cylindrical vessel, of sheet-copper or iron, say of six feet in height and three feet in diameter, (which would give a capacity of about 330 gallons.) This has two openings above, one, A, for the escape of gas, the other, B, for the admission of water, which is received from a reservoir or tank, placed at a convenient height, to secure a sufficient and not too heavy pressure. An opening, D, below is arranged on the bird-fountain principle, so as to allow a tube, delivering gas, to be introduced, and the water at the same time to pass out into the exterior basin, G, from which it escapes by a discharge-pipe, H, and is carried off by appropriate conduits out of the building. The upper openings are controlled by stop-cocks, this lower one is provided with a cap, as indicated, which is fastened with a screw clamp.

Fig. 7.



To manipulate this apparatus, the opening D is closed, while A and B are opened, the water entering by B, and air escaping through A. When the cylinder has thus been filled with water, A and B are closed, the cap is removed from D, and the end of the tube which delivers gas, from the retort or other apparatus used to develop it, is introduced through D, and the gas is thus collected, the water escaping as it is displaced. When all the gas desired has thus been introduced, D is again closed by its cap, connections are made between A and the ap-

paratus to be employed, and the cock B being opened, the gas is expelled as required, by the hydrostatic pressure of the water from the reservoir. A glass gauge is of great use with this apparatus, and may be easily attached by having two openings in the side of the cylinder, one near each end, (provided with stop-cocks in case of accident,) and connecting them by a glass tube, the joints being made with short pieces of rubber hose.

The dimensions stated above are very large, and are those of the two cylinders employed by Dr. Doremus, at the City College. At the Bellevue Medical College, the Doctor uses a smaller pair, and, of course, the size may be varied to suit all conditions. A moderate and regular head of water may also be obtained by the use of a small tank, with a ball-cock regulating its supply from the service-pipe; while further, to obtain uniformity in pressure, the cylinder may be placed not vertically but horizontally.

Grant's Gas Reservoirs.

The plan devised and carried out by Mr. Robert Grant, of New York, for storing gas, under heavy pressure, in strong iron cylinders, is one which, under certain conditions, possesses unparalleled advantages. The cylinders used are nine inches in diameter, of sheet iron one-sixteenth of an inch thick, and being about two and a half feet long, are closed by heads of $\frac{1}{8}$-inch iron, so corrugated as to give them additional strength, and are further secured by a stay-bolt, which occupies the axis of the cylinder. This bolt itself consists of a piece of $\frac{1}{2}$-inch heavy gas pipe, and at one end terminates in the stop-cock, which consists of a conical steel plug, forced, by a fine-threaded screw, on its own shaft, into a brass or iron seat. In size and taper, this plug or valve much resembles the point of a pencil case. It makes a valve, which may be easily rendered absolutely tight, and opened with great delicacy of graduation; a point of much importance with the high pressures employed, which, with any valve liable to be suddenly opened, would produce much such effects as are obtained with an air gun.

These cylinders are charged with the gas by means of a powerful condensing pump, run by steam, and are capable of safely resisting a pressure of twenty to thirty atmospheres. Their weight is about twenty-six pounds, and capacity one cubic foot; when fully charged, therefore, they will contain thirty cubic feet, or about two hundred and twenty-four gallons of gas, or about as much as seven pounds of

chlorate would yield, and as much as would fill between five and six 30 by 40 inch gas bags to their good working capacity. The gas adds but a small weight, (about two aud a half pounds for oxygen, and half this for burning gas,) and a boy may thus move from place to place a quantity of gas which, stored in any other way, would fill a wagon.

The merits of the system lie precisely in this, and are expressed in the words "ease of transportation."

In some cases it is desirable to employ a regulator for the outflow of the gas, by which its pressure may be restrained within narrow limits, and at a moderate amount from first to last, in a connected apparatus. Such a regulator, of a very efficient character, has been devised by Mr. Grant, and consists of one of the conical valves mentioned above, whose motion is controlled by a flexible diaphragm. One of these, which I have used for many months, operates in the most satisfactory manner.

(Continued from page 282.)

LECTURES ON ELECTRICITY AND LIGHT.

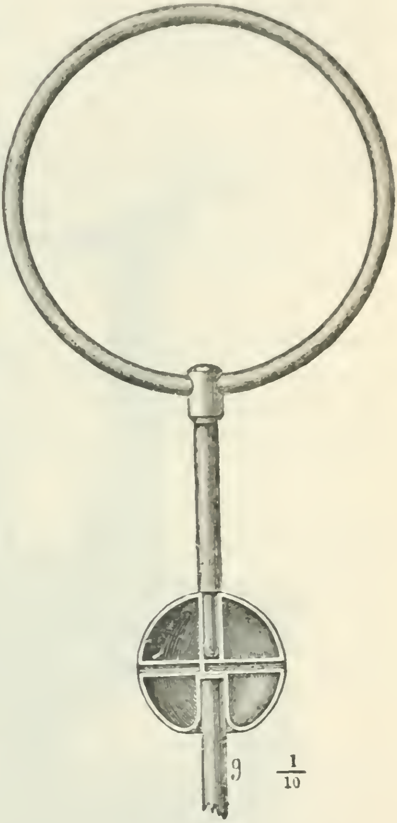
Delivered before the Franklin Institute, by PROF. HENRY MORTON, PH.D.

BEFORE the invention of improved instruments, (such as the Induction Coil,) by which an almost unlimited quantity of electricity can be easily obtained, large machines were much valued by reason of the above properties, and when Winter, of Vienna, advertised at very moderate prices, machines which were warranted to give sparks of extraordinary length, much wonder was excited among all conversant with the subject, as to the means by which such results could be reached.

Thus, he offered a machine capable of throwing a spark of two feet for $150, while that of Von Marum, before mentioned, gave no more than this and could not have cost much less than that of Mr. Ritchie, shown in our last number, and valued at $3000. In smaller machines, Winter's prices were equally remarkable. Thus, for $50, one was furnished capable of yielding sparks of from 12 to 14 inches; and for $25 one of 7 to 9 inches spark length; while, omitting other intermediate sizes, the smallest, offered for *six dollars*, gave sparks of 2 to 3 inches.

The reason of this anomaly soon appears on view of these machines. They are not larger than those of a *corresponding price* furnished by other makers; but they are all provided with a special contrivance by which their spark length is greatly increased. This contrivance consists of a large ring of dry polished wood (see Fig. 8) containing within it a wire which extends down the upright by which this is supported in the prime conductor, as shown in the cut. The prime conductor is in this case only a hollow ball. The diameter of the ring for the $25 machine (which has a plate of 15 inches diameter) is two feet, and for the other machines in proportion.

Fig. 8.



The structure of this machine is not, in other respects, remarkable. It is shown at Fig. 9 without the ring above described, which would be set by its stem in the prime conductor, *a*.

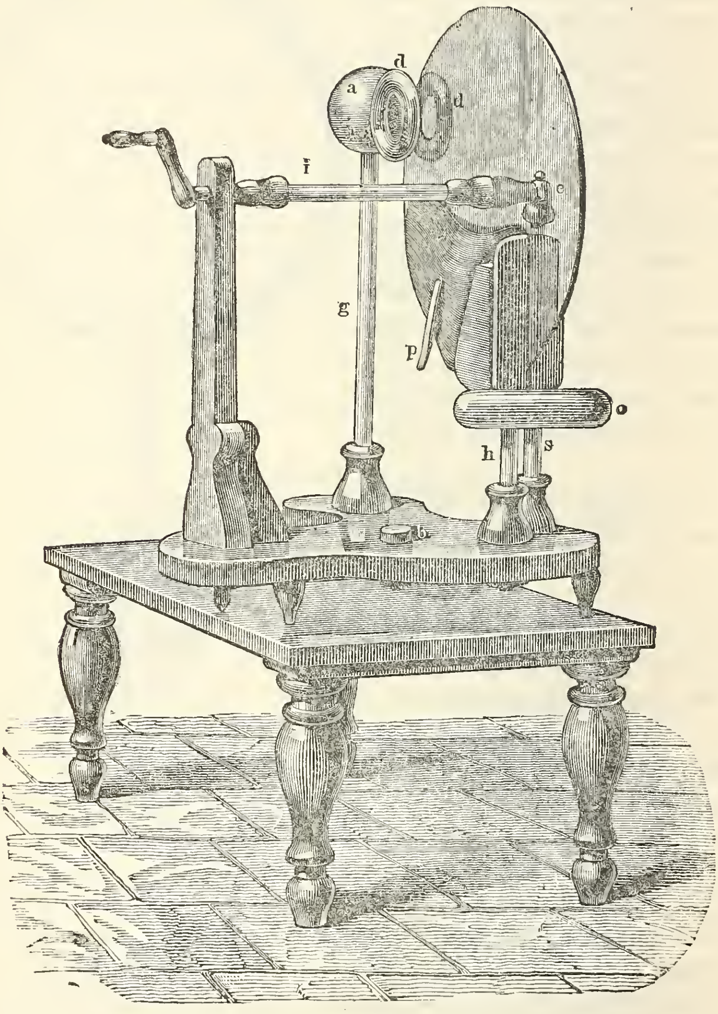
The plate is supported on a glass axle, *i*, the rubber is supported below on the glass upright, *h*, and terminates in silk flaps kept in place by nippers, *p*, when the machine is not in use. Two wooden rings, *d d*, provided with needle points on their interior surfaces, and coated in the same part with tin-foil, act as collectors.

Two of these machines are used by Prof. R. E. Rogers, and yield excellent results.

It is but fair to state that for some years before these machines of Winter's were announced, Mr. Trautwine, whose reputation as a civil engineer is so widely extended, had used a glass jar filled with metal foil as a means of adding length to the spark of an ordinary machine, which result it effects with great convenience and success.

A glass globe, internally silvered, such as is attached to their machines by Messrs. Queen & Co., of this city, is an effective and elegant modification of the same principle.

Fig. 9.



ERRATUM.

Description of Parhelium Observation at Germantown, on page 277, should read *February*, 1867, and not *February*, 1865.

Bibliographical Notice.

General Problems of Shades and Shadows. By S. EDWARD WARREN, C. E., Professor of descriptive geometry, &c., in the Rensselaer Polytechnic Institute. Published by John Wiley & Son, New York.

The work named above is one of great value to the practical draftsman, engaged in the execution of mechanical drawings for machinery or engineering structures, where accuracy of detail is of the first importance, and where the correct delineation of a shadow may be quite impossible in many cases, without the knowledge which the study of this book will give him.

To the architect, in an even greater degree, such a work will be of use, for with him the arrangement of his design must be in no small extent controlled by the effect which will be developed in the finished work by the "shades and shadows," which it will project within itself.

To the artist this will be of less importance, for it is the prerogative of his genius to convey the spirit of nature, not so much by accurate imitation, as by a poetic idealization of her forms. There is, however, a large class of able artists to whom, nevertheless, the above work will be of great value, and what with those whom we have enumerated, and others who might be added to the list, we should expect a pretty good demand for the work in question.

When we first opened the book and found fifteen large plates, which, though not "beautiful," (being geometrical projections simply,) are very well and carefully engraved on stone, and are, in many cases, very complicated; we were surprised to see that a publisher had been found so venturesome as to undertake such a work, but, on reading the preface, (the utmost which should be expected of a reviewer,) the mystery was explained by the statement, that "this expensive volume now appears through the kindness of students of the institute, in making up a liberal subscription in aid of its hitherto delayed publication."

In fine, this work on Shades and Shadows is a descriptive, geometrical treatise, explaining the methods to be pursued in projecting shadows of all kinds of objects, upon surfaces of all descriptions of curvature; and knowing this, all who want such a work will know that also, and, moreover, where to get it.

A COMPARISON *of some of the Meteorological Phenomena of* MARCH, 1867, *with those of* MARCH, 1866, *and of the same month for* SIXTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11¼′ W. from Greenwich. By PROFESSOR J. A. KIRKPATRICK, of the Central High School.

	March, 1867.	March, 1866.	March, for 16 years.
Thermometer—Highest—degree	61·50°	72·00°	78·50°
" date	31st.	15th.	3d, '61.
Warmest day—mean	53·00	62·00	66·00
" " date	31st.	15th.	3d, '61.
Lowest—degree	20·00	26·00	4·00
" date	15th.	18th.	10th, '56.
Coldest day—mean	25·67	28·50	11·50
" " date	18th.	26th.	16th, '56.
Mean daily oscillation	12·64	13·84	14·54
" " range	5·03	7·37	6·14
Means at 7 A. M.	34·14	37·18	35·84
" 2 P. M.	41·29	45·43	46·51
" 9 P. M.	37·32	40·85	40·35
" for the month	37·58	41·15	40·90
Barometer—Highest—inches	30·485	30·199	30·522
" date	15th.	1st.	3d, '52.
Greatest mean daily pressure	30·450	30·156	30·450
" " " date	15th.	1st.	15th, '67.
Lowest—inches	29·430	29·485	29·158
" date	2d.	16th.	17th, '54.
Least mean daily pressure	29·523	29·538	29·241
" " " date	2d.	16th.	22d, '65.
Mean daily range	0·235	0·161	0·194
Means at 7 A. M	30·032	29·893	29·855
" 2 P. M	30·002	29·822	29·800
" 9 P. M	30·015	29·862	29·836
" for the month	30·016	29·859	29·830
Force of Vapor—Greatest—inches	0·333	0·438	0·549
" date	1st.	15th.	18th, '59.
Least—inches	·060	·066	·023
" date	29th.	17th.	5th, '58.
Means at 7 A. M	·154	·173	·165
" 2 P. M	·159	·190	·179
" 9 P. M	·161	·193	·181
" for the month	·158	·185	·175
Relative Humidity—Greatest—per cent	95·0	95·0	100·0
" date	6th.	21st.	Often.
Least—per cent	23·0	29·0	16·0
" date	29th.	30th.	31st, '60.
Means at 7 A. M.	76·1	71·9	73·5
" 2 P. M.	60·2	57·8	53·8
" 9 P. M.	71·7	69·4	68·0
" for the month	69·3	66·4	65·1
Clouds—Number of clear days*	7·	8·	9·5
" cloudy days	24·	23·	21·6
Means of sky covered at 7 A. M	75·1 per ct	60·0 per ct	61·0 per ct
" " " 2 P. M	74·2	73·6	63·4
" " " 9 P. M	61·9	53·9	47·7
" " for the month	70·4	62·5	57·4
Rain and melted snow—Amount—inches	5·670	2·035	3·419
No. of days on which rain or snow fell	18·	11·	11·3
Prevailing Winds—Times in 1000	N 7° 51′ E·340	N58°14′W·294	N65°32′W·267

* Sky one-third or less covered at the hours of observation.

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. LIII.] JUNE, 1867. [NO. 6.

EDITORIAL.

Engineering Items.

Transmitting power with economy.—Methods of applying mechanical force which are not, on general principles, economical, may, notwithstanding, from special conditions involved in particular cases, be highly useful and practically thrifty. Such, for example, would seem to be the case with the various "hoists" in which hydraulic presses are caused to operate what we might call inverted "mechanical powers," and of which so many examples are now presenting themselves in the world of mechanical invention. In all these, a high velocity in the pumping engine is converted into a low one in the press, only to be again reconverted into a rapid movement in the application to the machine. This change implies a loss incurred in the various intermediate machines; but the convenience of transmitting the power by this means, in certain cases, compensates for all. The power is, we may say, condensed for transportation, and expanded when it gets to its work. This is the very reverse of the method which has received the name of Teledynamic, (τῆλε far off, δύναμις power,) where the force is transmitted at high velocities by very light running parts. An ex-

ample of this last is furnished in the "traversing cranes" of the Locomotive Works at Crew, (noticed in this Journal, Vol. LXIX., page 285,) driven by light cotton cords, running sixty miles per hour.

The same general principle is also about to be applied in some apparatus for the transmission of power from the engine-room to the hoists of the front premises of the Ledger Building, in this city, of which we hope, at a future time, to give a full account.

In each of these systems there is a loss,—in one case incurred in the act of transmission, from friction and the resistance of the air at these high velocities, and in the other, from loss of effect in the machines employed to transmute velocities at either end of the line.

In the cases, however, where an elastic fluid, such as air, is the transmitting medium, we have to add to the causes of loss last enumerated, the very important one of the energy expended in developing heat by the first compression, which heat is but imperfectly, if at all, recovered and utilized. That such a plan should prove of value, therefore, it is necessary that some especial adventitious benefit should be derived from the air employed, or the method must prove inferior to one of the others. In many cases of mining works, this may be derived from the supply of fresh air thus introduced. Such, no doubt, is the case in the Mont Cenis tunnel, where air, compressed by means of machines working on the principle of the hydraulic ram, is used to operate all the boring apparatus, while at the same time it provides thorough ventilation.

We meet with another example in the operations lately brought to a successful conclusion in the Ballarat mining district, New Zealand, as we learn from the *Mechanics' Magazine* for March, page 131.

At the mine of the Ballarat Tunnel Company, an engine has been erected at the mouth of the tunnel, for the purpose of compressing air, which is then carried into the interior of the mine, and employed at a convenient point to operate an engine, by which the lower workings are freed from water.

The compressed air is carried a distance of three thousand feet into the mine. As the authority above cited informs us, notwithstanding the jacket of running water with which the condensing air-pump is supplied, the first few hundred feet of pipe are nearly as hot as steam-pipe, while, on the other hand, the escape-pipe from the air-engine within the mine, is bearded with icicles. This reveals a serious loss, and were it not for the accidental advantage derived from the fresh air so introduced, there can be little doubt that this mode of

working would be found inferior in practical economy to other methods of transmitting power.

Surface condensers.—In a paper read before the English Institute of Naval Architects, by Robert Murray, C. E., we find some statements of great interest respecting the practical working of surface condensers, in connection with economy and the durability of boilers in marine engines. Referring our readers to page 365 of *Engineering* for full details, we may sum up the general conclusions as follows: 1st. The practical economy in the surface condenser depends essentially upon careful and moderate working of the engines, (by which means a good vacuum may be maintained,) and upon the high value of fuel, as in long voyages, by reason of which this item is made to assume large proportions. It is shown that for short and rapid trips, the use of surface condensers does not effect a good result; while on long voyages, as with the Indian mail steamers, the reverse is apparent, great care and intelligent management being included in this case.

2d. For the preservation of the boilers, it seems to be essential that a thin coating of scale should be produced and retained upon them. Failing this, the impurities introduced from the engine with the condensed steam, cause a very rapid corrosion and destruction of the plates.

To secure this protective coating, the boilers are filled with sea-water, and the density is allowed to run up to $\frac{1}{32^{1}/_{3}}$ of salt, and is so maintained until a thin scale is deposited, after which the density is carefully adjusted to about that which is the natural condition of sea-water. A less density causes the re-solution of the scale, which, if removed, must be again deposited as above directed.

Hydraulic whipping hoist.—In the Journal above quoted, we find described, under the above title, a hoist in which an hydraulic press has for its plunger a hollow screw, with steep inside thread. This being prevented by guides from turning, gives a rotary motion to a long male screw fitting within it, and carrying a winding drum on its outer end, which is properly supported. The machine constructed by Messrs. Hayward, Tyler & Co., London, is simply another of those now numerous applications of an *inverted* "Mechanical Power" operated by an hydraulic press.

Direct acting cranes, by M. Chrétien, which seem to operate with great success, follow the above-mentioned general plan. Here a long steam cylinder forms the lower part of the jib, and its piston-

rod, by separating a system of pulleys, gives the required range of motion to the lifting chain.

The effect of sudden strains on bolts.—We learn from *Engineering* that Major Palliser has developed some very remarkable facts in connection with the above subject, which may be readily demonstrated by very simple means. A light iron tripod is arranged, from the centre of which hangs an iron rod nearly to the floor. A 28-pound weight, with a hole in the middle, slides on this rod, to the lower end of which the bolt to be tested is screwed, with a large steel nut at its lower extremity. The weight being allowed to slide, or rather drop, down the rod, is arrested by the steel nut, and so communicates the shock to the bolt. With bolts three-eighths of an inch in diameter over the thread and two and a half inches long between the attached portions, two falls of the weight broke the bolt at the bottom of the first thread from the body, the body of the bolt having in this case the full diameter above given throughout. But where the diameter of the body was reduced to one-fourth of an inch, one-half of the former section being thus removed, the bolt bore ten blows, and then broke in the body, after stretching three-fourths of an inch, or about thirty per cent.

Here we have the secret of the whole affair. The whole force was sustained, in the first case, in a single instant; while in the second, the stretching distributed it over a greater time.

Steel boilers are now coming pretty largely into use on the locomotives of some French railways. Thus, twelve express engines of the Paris and Orleans Railroad are thus furnished, as also several on that of Paris and Sceaux, and on the Midi or Southern Railroad fifteen eight-coupled engines have steel boilers. The Orleans Company now employs cast steel plates for the circular smoke-boxes of all their engines, new and old, steel being thus substituted for iron when repairs are made.

Pumping engines of the Harlam Lake.—In the number of *Engineering* bearing date April 26th, we find a very interesting drawing and description of one of the engines used in draining the Harlam River.

A full account of the topographical relations of the locality in question, and of the engineering works there constructed, will be found in the United States Patent Office Reports for the Department of Agriculture, 1855, page 122. The chief peculiarity of the engines above noticed is, that they were made with two concentric cylinders, the cen-

tral one having a circular, the space between an annular, piston. The central piston was connected by one, and the annular by four, piston-rods to the same massive cross-head, from which power was communicated by means of walking beams, in one case to eleven, and in two others to eight, pumps. A constant vacuum was maintained below the annular piston. Steam being admitted beneath the central one, raised the mass of pistons, cross-head, counter weights, &c., in all about eighty-five tons, and by an hydraulic apparatus these are supported at the summit of the stroke until the pump-valves have had time to adjust themselves, when the steam from below the piston is allowed by an equilibrium-valve to pass above it, and also over the annular piston, because the inner cylinder terminates one and a half inches short of the cover. The weights raised and the unbalanced pressure on the annular piston now effect the down stroke.

The outer cylinder is twelve feet diameter, the inner seven feet, the stroke ten feet. The pumps are seventy-three inches diameter and ten foot stroke. The engine is calculated to raise sixty-six tons of water at each stroke. The entire amount of water removed in draining the lake was, by calculation, eight hundred millions of tons.

Models of the Suez Canal and its constructive machinery.—In one of the auxiliary buildings of the Paris Exhibition are exhibited a complete set of models illustrating the above work. One large model shows not only the whole of the maritime canal, from the Mediterranean Sea to Suez, but also the fresh water one, which, taken from the Nile at Cairo, runs first to Ismailia, and then in a line nearly parallel with the other to Suez.

Models of various important parts, on a larger scale, are also shown, as well as very complete ones of the various machinery used in excavating and removing the material. One of these machines is somewhat of a novelty, being a dredging machine, mounted on a truck, which runs on a broad tram-way beside the canal, and, excavating as it goes, throws over the material taken out into cars, which are run upon a parallel track at the other side of the tram-way.

The Pacific Railway.—Three hundred tons of iron have arrived at Council Bluffs, for the use of the Union Pacific Railway, and eight hundred tons more are on the way. This road—following the Platte route—is expected to reach a distance of six hundred miles from the Missouri before the season closes.

The Interoceanic Railroad.—The Costa Rica Interoceanic Railroad Company has contracted with Colonel Edward McGovern,

of Pennsylvania, to superintend the survey of the route conceded to them by the Costa Rica government. Colonel McGovern was lately employed on the railroad between Vera Cruz and the city of Mexico.

The new enterprise with which he has identified himself looks to the construction of a new railroad connecting the Atlantic and Pacific Oceans, having excellent harbors at its termini, and passing through a healthy, productive and populous region.

The Missouri bridge.—One hundred men are at work at the bridge now being erected across the Missouri River at Kansas City, Missouri.

French Railways.—In 1866 there were in operation in France eight thousand six hundred and seventy-seven miles of railway, which is four hundred and twenty-six miles more than were in operation during 1865. The gross receipts of these railways, in 1865, were $112,450,000 in gold, and in 1866 $120,700,000 in gold.

A twenty-inch gun was cast at the Fort Pitt Foundry, Pittsburgh, recently. One hundred and forty thousand pounds (seventy tons) of the best Juniata iron were placed in three furnaces, the largest quantity in one being sixty-eight thousand pounds, and the remainder about equally divided between the other two. The fires were lighted at four and a half o'clock on Monday morning, and in three hours and a half afterwards the furnaces were tapped, and the molten metal began flowing through conduits at opposite sides into the mould, which was filled in twenty-seven minutes, during which time a stream of water passed in and out of the core barrel at the rate of twenty gallons per minute, the water increasing in temperature in ten minutes from sixty to one hundred and ten degrees, and in forty minutes to one hundred and twenty degrees.

The casting was accomplished successfully, and without the slightest accident. The weight of the gun in the rough, when taken from the mould, will be about one hundred and forty thousand pounds, and when finished ninety-five thousand pounds; its greatest diameter ninety-four inches, at the muzzle thirty-eight by seventy inches; length, one hundred and eighty-nine inches; bore, one hundred and fifty-seven inches. The gun is intended for navy service, and is considerably shorter than others of like calibre heretofore cast. When finished, it will be tested at the proving ground, for which a ball weighing one thousand pounds will be used; also, nine charges of mammoth powder, the first three of sixty pounds each, the next three of eighty pounds, and the last three of one hundred pounds each.

A large engine.—The largest and most powerful locomotive yet owned by the Camden and Amboy Railroad is now being built at the company's machine works, in Bordentown. It is a ten-wheel engine, having six drivers four and a half feet in diameter. The cylinder is seventeen inches in diameter, with a stroke of twenty-four inches. It will be finished in a short time. It is intended that it shall have sufficient strength to draw one hundred cars, laden with coal, in one train.

Iron trade of Cleveland.—The magnitude of the iron trade of which Cleveland, Ohio, is the centre, may be seen from the fact that in one week three million one hundred and eight thousand pounds were received at, and one million four hundred and seventy thousand pounds were shipped from, that city.

Enlargement of the Erie Canal.—A bill authorizing this enlargement has already passed the Senate and been referred to the House committee. It proposes to increase the depth of water to six feet, and to enlarge the locks to a length of one hundred and ten feet between gates, and a width of twenty feet, which will enable the canal to pass boats carrying from two hundred and twenty-five to two hundred and fifty tons. The expense of running boats of this size will be but little more than that of running boats of sixty-five tons burden, the present capacity of the canal. With this enlargement, the expense of transporting coal from the vast coal fields, to Erie, will not be more than one-half or one-third what it now is. The bill provides for an equitable payment of all damages arising from this enlargement, under the provisions of the railroad law of 1859.

The Dismal Swamp Canal is being dredged and deepened. Its width is also to be increased from forty feet to sixty, and its locks extended twenty-five feet. When these improvements are completed it will accommodate ten times the present amount of business.

Cleaning marble, &c.—A new process for cleaning the façades of public buildings and dwelling houses is now being experimented on in Paris. A steam engine supplies pipes of gutta-percha with a constant stream of the vapor. These are applied to the stone or the brick surface of buildings, one man directing the steam-jet and the other using a brush. The building, after the application of this system, looks as clean and new as when erected. A couple of men in three days will thus wash the façade of a hotel at a great economy of time and money over the old mode of cleansing.

The new deposits of black band ore.—Nearly three thousand tons of black band iron ore have been shipped over the Mill

Creek Railroad since the discovery of this mineral in Schuylkill county.

Large salt springs.—A vein of salt water was struck at Lawrence, Kansas, a few days ago, while boring for water for a woollen factory. The water yields one-half pound of salt to the gallon. At that yield, the business of manufacturing salt is considered profitable in that section. Arrangements are already made to commence the manufacture, and it is expected by fall one hundred barrels per day will be produced.

American breech-loaders.—Sweden has adopted an American breech-loader for the use of her armies. Austria, France and other great powers have rejected the American patterns on account of their cost, and the length of time required to adapt machinery for their construction, although their general superiority is freely acknowledged.

Mechanical improvements.—A French writer on America expresses his surprise at observing that, under certain conditions, a young man is known as "the beau," however homely his appearance. It would seem, in like manner, that "attentions" addressed to the Patent Office entitles all things to the designation of "improvements," however *little improving* in their character. We thus find in one of our contemporaries "*improvements* in rotary and reciprocating engines," which consist in placing within a cylinder a loaded piston, without piston-rod or other attachment, and, by pushing this with steam from end to end of the cylinder, which is mounted on trunions, causing this last to execute a system of summersaults as effective and useful as those of the toy known under the name of Chinese tumbler.

Standard for bolts and nuts.—Plates have been prepared by Mr. Edward Lyman, of New Haven, Connecticut, containing exact working drawings of the various sizes of bolts and nuts, according to the system recommended by the Franklin Institute, in a resolution adopted December 15th, 1864, and now very generally followed in our largest workshops. Impressions from these plates, on sheets of strong paper, at a cost which is about one-eighth of that which would secure a similar drawing, are supplied to those desiring them, Messrs. J. W. Queen & Co., of this city, being the agents in charge of the sales for this State. The above system has been adopted by the government works, and will no doubt soon become universal.

The Louisville bridge, which is to span the Ohio at that place, will be a grand structure. Its entire length will be about three thousand six hundred and fifty feet, with a pivot bridge across the canal of

two hundred and eighty feet. The exact location is not yet established; but it will be between what is called the Elm Tree Garden and Rock Island. It will be reached by a grade of about seventy-eight feet to the mile on each side, for the distance of nearly three hundred and fifty yards. There will be twelve spans of two hundred and fifty feet each, with one large span of four hundred feet across the Indiana chute. The bridge will have an elevation of ninety feet above low water mark, and forty-nine feet above high water mark. The superstructure, which will be entirely of iron, will be one hundred and fifty-two feet above the foundation, and thirty-two feet above the floor. The cost of the bridge will be but little over half as much as that of the suspension bridge at Cincinnati. The Louisville and Nashville and Jeffersonville Railroads have each $300,000 stock in it, and private parties have $400,000. Hands are now at work quarrying the stone for the bridge, and it is purposed to have it completed by the year 1870. The progress of the enterprise has perhaps been somewhat retarded by the opposition of certain parties in that city, who claim it will be an injury to Louisville, because freight and passengers will pass through the city without paying their re-shipping duties to commission merchants, hotel keepers, etc. It is barely possible that the business of a certain class will be injured by it, but there is not the least doubt that the city will be amply compensated for such injury by the influx of trade from the other side of the river.

Novelties in Chemistry and Physics.

Wonderful illustration of vegetable growth.—Mr. Ernest Baudrimont has made the following calculations with reference to a fungus, the Lycoperdon giganteum, which, in fourteen days from its appearance above the ground, had reached a globular development of three feet three inches in diameter, and a weight of nearly seven pounds.

To obtain the carbon, found in its structure, from the atmosphere, this plant must have acted upon about 32,130 quarts of air per day, or about one pint per second.

This whole plant is composed of minute cellules, of which it must

have contained more than 14,500,000,000. To develop these in fourteen days, the plant must, on the average, have produced them at the rate of twelve thousand per second. The idea is absolutely beyond the grasp of a finite intellect. Between two beats of a pendulum, twelve thousand organisms produced within the limits of a cubic yard.

Reflecting telescopes, of glass, silvered by Liebig's process, have lately received, at the hands of the well-known optician, Mr. John Browning, a great practical development. Compared with refractors, the instruments now furnished possess the following advantages. They are half the length, of greater dividing power, quite free of chromatic aberration, more convenient in position to the observer, from one-fifth to one-tenth the cost.

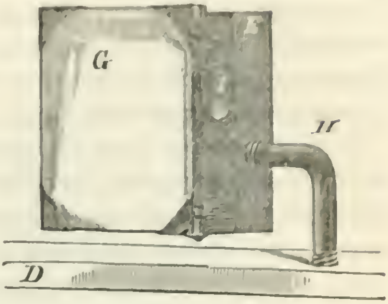
The silver surface, if tarnished, may be repolished by any one with a piece of soft leather; or if injured, can be replaced at a trifling expense.

Cheap lecture diagrams.—Under the above head we find in one of our contemporaries a description of the following plan. A sheet of paper is stretched on a board and then coated with a mixture of glue, water, lamp-black and ground pumice-stone. On this, when dry, the drawing is made with chalk and colored crayon, and fixed by going over the lines with water spray from an atomizer.

If a black ground is needed, this plan will no doubt prove satisfactory, but in all other cases we can recommend a far simpler one. If colors are required, draw on white paper with the wax crayons sold by the artist-stationers. We have for some time employed this plan, with great satisfaction, in the simpler description of diagrams, using for the more elaborate ordinary water colors. For mere black and white, the lithographic crayons used in drawing on stone make excellent diagrams, as we have lately seen from some prepared by Dr. C. M. Cresson, for his own use.

Multiple photographs.—To produce cheaply the small ambrotypes on varnished tin, which have been and are yet extensively manufactured, it is necessary to take, upon the same negative, many small repetitions of the same subject. This was formerly accomplished by using a camera with many lenses, and by exposing in this, in addition, different parts of the plate. This rendered the apparatus costly, the sitting long, and the manipulation difficult. A Mr. D. W. S. Rawson has removed these difficulties by a contrivance as ingenious as it is simple. He places opposite the sitter a box, filled with scraps of

looking-glass, each fastened to a block of wood, supported by a bent wire, as shown in the cut, so as to be readily adjustable. The camera, of any ordinary kind, with a single tube, is directed to these mirrors, and their multiple images are so taken. The account of this was first published in the *Philadelphia Photographer* for May, and we have since seen, at the office of its editor, Mr. Wilson, the apparatus and specimens of its work. The first strikes one by its simplicity, as does the second by its excellence. The error, due to double reflection from the two surfaces of the glass, is not appreciable.



New methods for the preparation of Oxygen.—From various publications lately made by the Abbé Moigno, in his own *Journal les Mondes*, and in the *Chemical News*, for which he has lately become the regular Paris correspondent, we learn many interesting particulars in reference to the above subjects. Thus, in the first place, he informs us, that a company, under the name of Jose de Susini & Co., with a capital of $400,000, has been formed in Paris, for the manufacture of oxygen under the patent of M. Archereau. This process, which we have before described, consists in the decomposition of sulphuric acid by heat, and the removal of the sulphurous acid by compression and consequent condensation, and by chemical absorption, leaving the oxygen in a pure state. The sulphurous acid is to be reconverted into sulphuric, by the usual process of the leaden chambers. From twenty-four pounds of sulphuric acid, of a density 60° Baumé, which is about the condition of that drawn from the leaden chambers before concentration, a cubic metre or 35·3 cubic feet (=two hundred and sixty gallons) of oxygen may be obtained.

It is calculated that by burning the ordinary illuminating gas with oxygen on lime, the amount of illumination obtained with a given quantity of the former, is increased about eight-fold, as compared with its ordinary burning in the atmosphere; while the increase in cost, by reason of the oxygen supplied by the process above, would be about four times, showing a gain of one hundred per cent. This calculation we have modified from that of the Abbé, who allows but half a measure of oxygen to each measure of burning gas. This, we sup-

pose, must be an oversight, as we know, from actual experience, that illuminating gas requires practically an equal volume of oxygen for its thorough combustion. The practicability of the above plan on a commercial scale, as the Abbé remarks, has yet to be proved, and the above correction of the previous estimate does not improve the prospect of profit in the enterprise.

Another process, to which allusion has been made before, is that of M. M. Tessié de Mothay and Maréchier, of Metz. This consists in the superoxidation of the manganate of soda by a current of hot air, and the deoxidation of the permanganate so formed by a current of steam. Each two and a half pounds of the salt will yield at each treatment about eighteen gallons of oxygen, and there is no waste of material. An apparatus working on this principle, and capable of yielding about one hundred and seventy-five cubic feet, or thirteen hundred gallons of oxygen per day, is being put up, on the Champ de Mars, in a laboratory adjoining the lecture-room appropriated to the Abbé, where it will be employed, among other things, in furnishing gas for the illumination of that hall. The lamp employed in this case will be that of M. Carlevaris, of Genoa, in which a combined jet of illuminating gas, or of naptha vapor, with oxygen, is directed upon plates of magnesia and chloride of magnesium united.

Another process may well be recalled in connection with these two, although it has, we think, been mentioned before. It consists in exposing subchloride of copper (Cu_2Cl) to the air, until it absorbs oxygen enough to convert it into the oxychloride ($Cu\,Cl\,Cu\,O$), and again returning this to its original state, by the application of heat. This process, devised by M. Mallet, was lately introduced to the French Academy by M. Dumas. We observe, in the notices of patents, that protection for this process is in course of being secured by its inventor, in England. Many years ago a plan analogous to the second of those above, in which protoxide of barium ($Ba\,O$) was first oxidized by air and heat, and then reduced by steam, was published and commended, but seems to have passed into oblivion without any (at least recorded) trial of its merits.

Arsenuretted hydrogen may be distinguished or separated from antimoniuretted hydrogen, by passing the suspected or mixed gas through a tube containing solid pieces of caustic potash. The antimony, if present, will be here deposited as a brilliant metallic coating, while the arsenuretted hydrogen will escape without decomposition. For further particulars see *Chemical News*, page 150.

Hypochloride of magnesia, for bleaching, possesses the following advantages over the corresponding salt of lime, when delicate tissues are to be treated: 1st. It decomposes more easily. 2d. The liberated magnesia has no action on the tissues. It is best prepared by decomposing sulphate of magnesia with hypochloride of lime. If manganese is present, the liquid loses its bleaching power, and acquires a red color. (See as above.)

Extract of meat.—Some remarkable facts, not generally appreciated, seem to be developed by the evidence brought before the sub-committee on Food, of the Society of Arts. Thus it would appear that extract of meat, even that prepared by Liebig's process, is less important as a nutritious body than as a means, like tea and coffee, of preventing waste in the tissues. The statement was made that "a teaspoonful of extract did not contain as much nutriment as a mouthful of meat." "But one-fifth to one-eighth of the solid constituents of meat pass into the extract." The rest of the evidence, so far published, is to the same effect. The process of Professor Gamgee for preserving meat, in which the pickling process is conducted (it is said without pain) upon the living, or rather dying animal, is to be thoroughly tested before the same committee. See, for full account of the above, *Chemical News*, page 161.

Preservation of meat, by a process which bears much analogy to the Burnetizing of timber, is exhibited at the Paris "Exposition," and is highly commended by the Abbé Moigno. It is devised by M. François Cerio, of Turin, and is conducted as follows: The meat to be treated is, as soon as possible after killing, placed in a closed vessel, from which the air is exhausted by a pump. After this the brine is admitted by an appropriate tube, and allowed to remain in contact with the meat for a few minutes, which will suffice for a thorough action. The meat is then removed, and packed, or allowed to dry, as occasion may require.

Artificial meerschaum, as we learn from M. Holdman, in the *Chemical News*, is prepared by mixing one hundred parts of silicate of soda at 35° (we presume a solution at 35° Baumé) with sixty parts of carbonate of magnesia and eighty parts of native meerschaum, or of pure alumina. This mixture is carefully pulverized and finely sifted, boiled with water and put in porous moulds.

Plaster of Paris, when mixed with alum, forms an excellent cement for use in the laboratory. This recipe is an old one, but good enough to bear recalling to mind.

Organic matter in water, its test.—Professor Frankland, in a lecture lately delivered before the Royal Institution, shows that permanganate of potash is anything but a satisfactory test of the amount of organic matter present in water. Thus, of seven organic bodies tried, the actual amount in each case being three grains, this test indicated, respectively, ·082, ·051, ·114, ·634, ·064, ·074 and ·074 grains, or, in the best case, but about one-fifth of the true amount.

A lightning flash struck the light-house at Fecamp, creating great havoc, though the edifice was provided with a rod, carried into a cistern, *thickly lined with Portland cement.* The atmospheric electricity of that locality evidently objects to entering anything like a Leyden jar, after the same has been fully charged by its previous action.

Alcohol from the Jerusalem artichoke.—M. Dubrunfraut finds that the juice of these roots, properly fermented, yields eight to nine per cent. of concentrated alcohol.

Ingots of indium, at the Paris Exhibition, weighing about fifteen hundred grains, and valued at about $3600, are exhibited by M. Richter, of Friburg, one of the companion discoverers of this element.

Electric instruments of registration.—We have received from Messrs. Edmonds and Hamblet, of Boston, a descriptive catalogue of various instruments, a knowledge as to the existence of which may be useful to some of our readers. The first of these is the **electric watch clock**, which records, with great precision as to time, the performance of various duties, such as those of the night watchman in a large establishment, those of a boiler tender in trying his gauge-cocks, and the like. It may be connected with every part of a large establishment, without the least risk of becoming inefficient through change of temperature, or stretching of wires, as with the merely mechanical instruments of a like character. The battery being only intermittently in action, never requires attention more than once in six months. We next find the **electric pendulum gauge**, which records at any distance, either at stated times or at any moment, on application, the condition of a gas-holder, reservoir, or the like. Without attempting to explain the details of this apparatus, which, without figures, it would be almost impossible to accomplish, we may say, generally, that by depressing a key, either by the hand at *any* time, or by clock-work mechanism at *stated* times, an electric current is initiated, which at the distant reservoir liberates and keeps

in motion a pendulum, with which is connected machinery whose range of continued motion is limited by the position of the gas-holder, the level of the water in a reservoir, or the like. The pendulum, therefore, makes more or fewer vibrations, according to the state of these recipients, and as each vibration makes and breaks circuit in the original current, this easily operates a recording apparatus at the other end of the line. Again, we find a sytem for **plural time dials**, which possesses many points of originality and merit, and lastly, a **magneto electric alphabetic telegraph**, which requires no battery, the electric force being obtained from a magneto-electric machine, worked by the operator when he is using the instrument.

The Brooks insulator.—In the *Telegrapher* of April 15th we find, in full, a report made by Dr. C. M. Cresson to Wm. J. Philips, Superintendent of Police and Fire Alarm Telegraphs, on various insulators submitted for examination. We have only space here for the general practical result, which may be well expressed by the following extract:

"Repeated trials made upon the whole of the samples, side by side, exposed to a continuous shower of water, gave results as follows (the comparison being made in the consumption of zinc derived from actual trials, in the production of equal deflections of the astatic needle by battery power):

No. 1 (Wades'),	over	35
No. 2 (Lefferts'),	"	30
No. 3 (glass and bracket),	"	80
No. 4 (Brooks'),	less than	1
No. 5 (rubber-covered book),	"	28
No. 6 (English),	"	16

"From this it would appear that the wooden covering of Nos. 1 and 2, actually took away from the insulating powers of the inclosed glass, which glass was very similar in form to No. 3.

"A close examination of Nos. 3, 5 and 6, revealed a surface full of minute pores or cracks, capable of absorbing water and of retaining it.

"The Brooks Insulator alone remained intact during all conditions, and it was assumed for the sake of comparison, that the deflection was 1°, although the motion of the needle was too small to be read off on the scale; whilst the insertion in the circuit of No. 1 caused a deflection of over 45°. The success of the Brooks Insulator was entirely due to the use of paraffine, with which the glass and sulphur (in the different specimens presented for trial) were completely saturated,

filling up all the minute pores and crevices, and rendering the surface of the insulating medium repellant of water.

* * * * * * * *

"The Brooks Insulator, constructed with an iron case with the wire hook secured into it by glass or sulphur, and the whole thoroughly saturated with paraffine and provided with a shedding collar of porous earthenware, likewise saturated with paraffine, seems to me to combine all of the requisites for complete success."

OUR NEW YORK CORRESPONDENCE.

New York, *May* 27, 1867.

Despite the dullness that hangs over this great city, projects of considerable engineering interest are being discussed, which, if carried out, will make New York of more metropolitan greatness than ever, and a more worthy stopping place between the Continent and the Oriental East, when the boasted Pacific Railroad is completed. First and foremost is the problem of rapid transit from the suburbs to the heart of the city, and for this purpose numerous plans are proposed, some utterly absurd, some problematical and some really practical—all, however, costly from necessity. The last Legislature, for some "wise purpose," refused to grant a franchise for any scheme, but graciously passed a bill to allow one applicant to build a half mile of experimental line, and if successful, to encircle the city with it. This is the West Side and Yonkers Elevated Railway Company, who expect, by middle of summer, to show what they can do. However, for the present, we will drop this interesting question until another writing, when I will endeavor to lay all the schemes before you, and devote my space to them alone. I hardly know whether the East River Bridge is a fixed fact or not, for the holders of the franchise are interested in the long established ferry companies, the President of the Bridge Company being the *counsel* for this antagonistic interest. However, be that as it may, a form of organization has been gone through, and the necessary committees appointed, with John A. Roebling as Chief Engineer. Surveys have been ordered, to determine the best line of crossing, upon the completion of which subscribers to the stock may be advertised for. The charter gives unlimited time to finish the work, and a generous allotment for the commencement of

it. As far as I can learn, the plan in general will be of the suspension class, with three sets of cables, carrying a platform properly stiffened, to accommodate the crossing of at least two hundred and fifty thousand persons daily. To do this, the platform would be broken up for two carriage-ways, thirteen feet each; two car-ways, sixteen feet each; and a foot walk, seven feet wide on either side. This would require four cables and in all about seventy-five feet of width. The height of platform above high water, at centre of bridge, would be about one hundred and thirty feet, grading down each way to only a hundred feet at the abutments. The cars for crossing are intended to be large and roomy, and to be operated by stationary engines and an endless belt or rope. Three minutes is the time estimated to be required from Main Street, Brooklyn, to City Hall, New York. It is expected that six millions of dollars, at farthest, will complete the work. Without going into a more critical examination of this plan, it would seem that the steep grade adopted would concentrate all the tall-masted shipping in the centre of the river, and seriously interfere with navigation. An interesting experiment upon block-tin water pipes came off in this city a few days ago. A great many efforts have been made to substitute some kind of piping for the injurious lead pipe, so long employed, but none have been crowned with such complete success as that made by drawing from tin encased with lead. The process is as follows: A solid cylinder of tin, weighing, say, fifteen pounds, is bored of a certain diameter. It is then placed in a larger cylinder, having poured around it melted lead. A powerful hydraulic press forces it through a gauge, (just as in wire drawing, a steel rod forming, as it were, the core. The line of contact of the lead and tin is clearly defined, and the pipe is a very perfect one. The following are the results of some of the experiments: An ordinary leaden pipe, one inch interior diameter, and weighing four pounds eleven ounces per foot, burst at pressure of one thousand pounds on gauge. A tin-coated pipe, of like capacity, but weighing only two pounds six ounces per foot, required eleven hundred and fifty pounds to burst it. A three-quarter inch lead pipe, weighing three and eight-tenths of a pound per foot, required a pressure of twelve hundred pounds before bursting. A tin-coated pipe of the same calibre brought the dynamometer up twelve hundred and seventy-five before bursting; this last weighed only one and twelve-hundredths pounds per foot. About the same ratio was kept up with other sizes experimented upon, showing a great saving in weight, with a com-

mensurate gain in strength. As no injurious chemical action takes place between water and the tin lining, we must hail this improvement in water-pipes as a long needed and beneficial one, which, when once well known, will meet with unbounded success.

The Hudson River Railroad Company is erecting upon the site of St. John's Park a large fire-proof freight depot, in three stories. The building will cover an area of little over four acres, being four hundred and thirty-eight feet on Hudson and Vesey, and four hundred and five feet on Beach and Laight Streets. The area will be broken up by five double-track pitways, to accommodate the various freight lines converging upon this railroad. The lower floor will be, of course, devoted entirely to depot purposes, while the upper ones will be arranged for required offices and storage rooms. Steam elevators will be located at intervals, to do all the hoisting for the warehouses. There will be a central area of about one hundred by one hundred and forty feet left by the warehouses, which run back but one hundred and fifty feet from each street. The present intention is to cover this area with glass and iron, but this, like a great many other projected features, is entirely at the mercy of the eccentric presiding genius of the company, and it will be a very difficult matter to tell how the building will be, until completed. It has been decided, however, to make the elevated platforms russ pavements.

In my next I will send diagrams, &c., illustrating one of the most marked improvements in locomotive boilers, for the more perfect consumption of gases. I am awaiting the results of some experiments, or you should have it at this writing. A. P. B.

Encouraging views of American affairs are not often announced from the other side of the Atlantic; but in the *London Economist*, of a late date, we find an article of which the following extract is a fair sample. "The United States have still the best possible land, the best mines, the best things above ground, the best things under ground, and an educated Anglo-Saxon race to make use of all of them. Such means and materials for production, and such skill in making, the world has never seen together. In consequence, wealth is created faster than ever before, and the government can tax it much more readily."

Civil and Mechanical Engineering.

FORMULAS AND TABLES FOR THE SHAFTING OF MILLS AND FACTORIES.

By JAMES B. FRANCIS, Civil Engineer.

THE following investigation was undertaken at the request of General John C. Palfrey, the Agent of the Merrimack Manufacturing Company, of Lowell, Massachusetts, for the purpose of determining the relative fitness of wrought iron and steel for the shafting of a cotton factory now erecting by that company.

Samples of steel, all of American manufacture, were obtained from different makers, and, together with several samples of iron, were subjected to experiment.

The constant expressing the resistance of cylindrical bars to torsion, I deduce from Navier's formula,*

$$T = \frac{16\, W R}{\pi\, d^3}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1.)$$

in which,

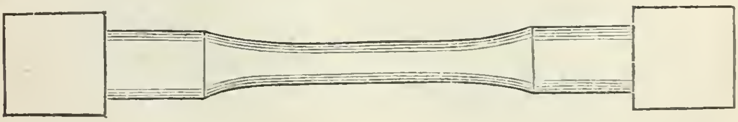
T = a constant for the same material.

W = the weight, in pounds, which, if applied at the distance R, in inches, from the axis, will just fracture the bar.

π = the ratio of the circumference of a circle to its diameter.

d = the diameter, in inches, of the bar at the place of fracture.

The bars subjected to torsion, were finished in the form of the following diagram; the ends being two inches square, and the middle turned down to a diameter of $\frac{3}{4}$ inch, in order to insure the fracture taking place in that part of the bar.



The weight producing the torsion was applied at the end of a lever, of the effective length of 35·975 inches, fitted to the square boss at one end of the bar. The tendency of the bar to revolve

* Resumé des Leçons sur l'application de la mécanique.

under the action of the weight, was controlled by a worm-wheel about fifteen inches in diameter and one hundred and thirty-eight teeth, fitted to the square boss at the other end of the bar. This wheel could be moved through any arc by means of a worm. As the bar became twisted by the torsional strain, the worm-wheel was moved through an arc sufficient to bring the lever to an horizontal position.

A graduated circle on one face of the worm-wheel, furnished the means of measuring the arc of torsion.

The effective weight of the lever and scale at 35·975 inches from the axis, where the scale was hung on a knife edge, was 48·5 pounds, and was the least effective weight which could be applied to produce torsion.

EXPERIMENTS ON TORSION.

DESCRIPTION OF THE BAR.	Mean diameter of the reduced part of the bar, in inches.	Arc of torsion just before fracture.	Weight producing fracture, in pounds.	Mean temperature of the air.	Value of **T**
English refined wrought iron, from a bar two inches in diameter, marked A, 13	0·750	416·8°	113·17	58·8°	49,148
Same, marked 13	0·750	596·0°	125·69	66·0°	54,585
Wrought iron, from the Pembroke Iron Works, Maine, marked 14	0·753	641·3°	143·72	62·3°	61,673
Decarbonized steel, from the Farist Steel Company, Windsor Locks, Conn., from a bar two inches square, marked B, 6	0·752	390·5°	192·48	70·2°	82,926
Spindle steel, from the same, from a bar two inches square, marked A, 5	0·750	284·3°	235·17	68·3°	102,131
Steel, from the Nashua Iron Co., Nashua, N. H., from a bar two inches square, marked 2	0·751	611·3°	198·73	65·5°	85,961
Same, marked *d*, 2	0·752	557·0°	203·23	63·7°	87,557
Steel, from same, from 1¼ inch octagonal bar, marked 4	0·752	475·0°	221·0	67·5°	95,213
Same, marked 3	0·751	508·3°	217·25	61·2°	93,972
Steel, from the works of Hussey, Wells & Co., Pittsburgh, from a bar two inches square, marked E, 1	0·751	308·0°	202·66	63·6°	87,661
Same, marked 1	0·748	297·3°	196·50	68·0°	86,023
Bessemer steel, from the works of Messrs. Winslow & Griswold, Troy, N. Y., from a bar two inches square, marked 16	0·748	215·5°	181·97	66·0°	79,662
Same, marked 16 x	0·748	268·5°	174·50	67·0°	76,392

The experiments on deflection were made on round bars turned to a diameter of about one inch. The distance between the points of support was forty-eight inches. Observations were made of the deflections produced by a weight of one hundred and fifty pounds suspended at the middle point between the supports. This weight was not sufficient to cause any sensible set in the bar after the weight was removed; and no sensible increase in the deflection was produced by allowing the weight to remain suspended on the bar for several days.

The constant E for deflection, has been computed by Navier's formula,*

$$s = \frac{l^3 \text{W}}{6 \pi d^4 \text{E}}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2,)$$

in which

l = the distance between the points of support, in inches.

W = the weight at the middle point between the supports, in pounds.

π = the ratio of the circumference of a circle to its diameter.

d = the diameter of the bar, in inches.

s = the deflection at the middle point between the supports, in inches.

EXPERIMENTS ON DEFLECTION.

DESCRIPTION OF THE BAR.	Diameter of bar at the middle, in inches.	Deflection, in inches.	Mean temperature of the air.	Value of **E**
Spindle steel, from the Farist Steel Co., Windsor Locks, Conn., from a bar 1 1-16 inches in diameter, marked A, 7..........	0·995	0·2330	48·0°	3,853,590
Same, marked A x 7..................................	0·977	0·2315	53·8°	3,847,530
Decarbonized steel, extra, from the Farist Steel Co., from a bar 1 1-16 inches in diameter, marked A A x.....................	0·993	0·2310	53·0°	3,918,360
Same, marked A A 8................................	0·995	0·2327	53 7°	3,858,557
Decarbonized steel, from the Farist Steel Co., from a bar 1 1-16 inches in diameter, marked 9 x B..................................	0·992	0·2330	54·2°	3,900,420
Same, marked 9 B..................................	0·995	0·2307	53·3°	3,892,008
Steel, from the works of Hussey, Wells & Co., Pittsburgh, from a bar 1 1-16 inches in diameter, marked 15..........................	0·998	0·2337	52·2°	3,796,000
Same, marked 15 x..................................	0·996	0·2337	49·8°	3,826,641
Bessemer steel, from the works of Messrs. Winslow & Griswold, Troy, New York, from a bar 1 1-16 inches in diameter, marked 17 x..................................	1·000	0·2330	49·4°	3,777,095
Same, marked 17..................................	1·000	0·2315	52·0°	3,801,560

* See the number of this Journal for February, 1862.

Several specimens of the steel have been tested for tensile strength, at the works of the South Boston Iron Company, by Mr. F. Alger, in the apparatus designed by Major W. Wade, for testing metals for cannon, a description of which may be found in *Reports of Experiments on the Strength and other Properties of Metals for Cannon*, published in 1854, by authority of the Secretary of War.

EXPERIMENTS ON TENSILE STRENGTH.

DESCRIPTION OF THE SPECIMEN.	Diameter at the place of fracture, in inches.	Weight producing fracture, in pounds.	Tensile strength per square inch in pounds.	Specific Gravity.
Spindle steel, from the Farist Steel Co., Windsor Locks, Conn., marked A 10 A 1	0·597	40,800	145,754	7·8401
Same, marked A 10 A 2	0·598	39,500	140,639	7·8287
Decarbonized steel, from the same, marked B 11 B 1	0·596	34,500	123,662	7·8583
Same, marked B 11 B 2	0·597	35,200	125,750	7·8514
Decarbonized steel, extra, from the same, marked A A x 1	0·600	30,500	107,862	7·8417
Same, marked A A x 2	0·600	30,900	109·271	7·8579
Same, marked A A x; ends upset in order to form the specimen	0·600	30,800	108,901	7·8484
Same as next preceding specimen, marked A A x 2	0·600	29,700	105,053	7·8534
Steel, from the works of Hussey, Wells & Co., Pittsburgh, marked c 12, 1	0·594	40,400	145,790	7·8530
Same, marked c 12, 2	0·594	40,200	145,070	7·8496

I find on record many experiments on the fracture of iron and steel by torsion, from which I deduce the following values of T; using the above formula for cylindrical bars, and Navier's formula,

$$T=\frac{3\sqrt{2}\,WR}{b^3}, \quad . \quad . \quad . \quad . \quad . \quad . \quad (3,)$$

for square bars, in which b = the side of the square in inches, and W and R the weight in pounds, producing fracture, and the distance from the axis in inches, at which it is applied.

EXPERIMENTS BY RENNIE, given in the *Philosophical Transactions of the Royal Society, for* 1818.

Bar of English wrought iron, 0·25 inch square, ...T = 65,982
Bar of Swedish " 0·25 " ....T = 61,909
Bar of shear steel, 0·25 " ....T = 111,191
Average of 3 bars of iron cast horizontally, 0·25 in. sq., T = 64,776

EXPERIMENTS given in the fifth edition of *Haswell's Engineers' and Mechanics' Pocket Book.*

Bar of Ulster Iron Co.'s wrought iron, one inch diameter, T = 87,090
Bar of Swedish " " " T = 93,965

EXPERIMENTS made at the Royal Gun Factories, Woolwich, England, on many varieties of cast iron. *Parliamentary Document ordered to be printed July 30, 1858.*

Experiments are given on fifty-one varieties of British cast iron, besides several varieties from other countries. I select the experiments on four varieties of British iron, viz: the strongest, two of medium strength, and the weakest; each result being deduced from a mean of several experiments on bars about 1·8 inch in diameter.

From West Hallam Iron Works, Ilkeston ....T = 38,217
" Netherton Iron Works..................................T = 31,490
" Butterley " ....T = 33,949
" Hæmatite Iron Company..................................T = 22,132

EXPERIMENTS made at the Fort Pitt Foundry, in 1846, on bars of different forms and dimensions, of common foundry iron, given in *Reports of Experiments*, &c., above cited.

Bar about one inch square..T = 36,846
" 1·415 inch square..T = 34,443
" about 1·749 inch square..T = 42,821
" 1·135 inch in diameter..T = 37,445
" 1·595 " " ....T = 42,047
" 1·955 " " ....T = 38,851

EXPERIMENTS made at the West Point Foundry, in 1851, on Greenwood iron of different grades, mixtures and fusions, given in *Reports of Experiments*, &c., above cited.

Mean deduced from eighteen experiments on bars about 1·9 inches diameter..T = 44,957

The value of E, for wrought iron, I have previously deduced from English experiments, and tested by a single experiment on a shaft two inches in diameter and about 180 inches between bearings.* From these experiments I find..........................E = 3,492,539

There being such great irregularities in the values of T, it will not be safe, in practice, to take a mean value, but one near the lowest value.

* See the number of this Journal for February, 1862.

The values for wrought iron vary from 49,148 to 93,965. For safety, I take for wrought iron..T = 50,000
The values for steel vary from 76,392 to 111,191. For safety, I take for steel..T = 80,000
The values for cast iron vary from 22,132 to 64,776. For safety, I take for cast iron..T = 30,000
I also take for wrought iron..E = 3,500,000
And for untempered steel..E = 3,800,000

Shafts for transmitting power, are subject to two forces, viz: transverse strain and torsion. In shafts of wrought iron or steel, in which the bearings are not very near to each other, a transverse strain, too small to cause fracture, will produce sensible deflection; if this is too great, it will produce sensible irregularities in the motion, and tend towards the rapid destruction of the shaft and its bearings. This limits the distance between the bearings, as the weight of the shaft itself will produce an inadmissible amount of deflection whenever this distance exceeds a certain amount, which varies with the material and diameter of the shaft.

The deflection of a cylindrical shaft from its own weight, supported at each end, but disconnected from other shafts, is given by the formula (4), which is deduced from Navier's formula for the deflection of a cylindrical bar. *See Journal of the Franklin Institute for February*, 1862.

$$\delta = 0{\cdot}007318 \frac{l^4}{d^2 \mathrm{E}}, \quad . \quad . \quad . \quad . \quad . \quad (4.)$$

If the several parts are so connected as to be equivalent to one continuous shaft, it will correspond to the case of a beam fixed at both ends, for which case Barlow* gives δ equal to two-thirds of its value in the case of a beam supported at both ends, given by formula (4). Navier†, taking into account the effect of the deflection in the adjacent divisions, finds δ equal to one-fourth of its value by formula (4). In order to decide which of these eminent authorities to follow, I have appealed to experiment.

Experiment 1. A bar of wrought iron purchased as "English refined," 12 feet 2¾ inches long, 0·367 inch deep, 1·535 inch wide, was supported at four equidistant points, four feet apart. When loaded at the middle points of each division with fifty-two pounds, the deflection in the middle division was 0·069 inch, and the

* Report of the third meeting of the British Association for the Advancement of Science.

† Résume des leçons sur l'application de la mécanique.

mean deflection in the other two divisions was 0·371 inch. The weight on the middle division was then increased until the deflection was alike, viz: 0·281 inch in each division; the weight being 82·84 pounds in the middle division, and 52·00 pounds in each of the other divisions. Four feet was then cut off of each end of the bar, when the deflection, with 82·84 pounds on the middle division, was 1·102 inch.

Experiment 2. A bar of iron of the same quality and length as in experiment 1, 0·551 inch square, was laid on the same supports. When loaded at the middle points of each division with fifty-two pounds, the deflection in the middle division was 0·058 inch, and the mean deflection in the other two divisions was 0·314 inch. The weight on the middle division was then increased until the deflection was 0·241 inch in each division; the weight being 82·84 pounds in the middle division, and 52·00 pounds in each of the other divisions. Four feet was then cut off of each end of the bar, when the deflection, with 82·84 pounds on the middle division, was 0·984 inch.

In the case in which the deflections were alike in the three divisions, the middle division corresponds to the case of a continuous shaft supported by numerous equidistant bearings, and the case where the bar was reduced in length, corresponds to that in formula (4). Comparing the deflections in the two cases in the above experiments, we find by experiment 1, that the ratio of the deflection of the shaft, simply supported at each end, to that of the continuous shaft, is as 1 to 0·255. In experiment 2, the corresponding ratio is as 1 to 0·245; the mean of the two experiments giving a ratio of 1 to 0·25,* which agrees with Navier, and we must adopt for the deflection of a continuous shaft, from its own weight, the formula

$$\delta = \tfrac{1}{4} \times 0{\cdot}007318 \frac{l^4}{d^2 \mathrm{E}}, \quad . \quad . \quad . \quad . \quad (5.)$$

The greatest admissible value of δ in proportion to the length, must be determined by experience. Tredgold assumes that for cast iron, it might be 0·01 inch for each foot in length, or $\frac{1}{1200}$ part of the

* These experiments indicate the effect of connecting the chords of truss bridges over the piers. Assuming that in a bridge of not less than three equal spans, the top and bottom chords have equal resisting powers, and the whole length of the bridge is uniformly loaded, if the chords are continuous throughout the whole length of the bridge, the deflection of any span, except the end spans, will be one quarter of the amount that it would be if the chords were disconnected at the piers.

length, *whatever may be the diameter;* but the transverse strain to produce this deflection, is a greater fraction of the transverse strain that will produce fracture in a large shaft than in a small one. The maximum strains of extension and compression in a shaft, for the same deflection, are in proportion to the diameter, while the deflection itself, from the weight of the shaft, is inversely as the square of the diameter; consequently, the deflection to produce the same maximum strains, must be inversely as the diameter.

Adopting this principle and the assumption that a shaft of wrought iron or untempered steel two inches in diameter, may deflect from its own weight, 0·01 inch per foot in length between the bearings, we may determine the greatest admissible distances between the bearings of shafts of other diameters, as follows:

The greatest admissible deflection for any diameter d, is

$$\delta=\frac{2l}{1200\,d}=0{\cdot}00167\,\frac{l}{d}, \quad . \quad . \quad . \quad . \quad . \quad (6.)$$

Substituting this value of δ in (5) and reducing, we have

$$l=\sqrt[3]{0{\cdot}9128\,d\,\mathrm{E}}, \quad . \quad . \quad . \quad . \quad . \quad (7.)$$

TABLE *of the greatest admissible distances between the bearings of continuous shafts, subject to no transverse strain except from their own weights; computed by formula* (7).

DIAMETER OF SHAFT, IN INCHES.	Distance between bearings, in feet.	
	If of wrought iron	If of steel
1	12·27	12·61
2	15·46	15·89
3	17·70	18·19
4	19·48	20·02
5	20·99	21·57
6	22·30	22·92
7	23·48	24·13
8	24·55	25·23
9	25·53	26·24
10	26·44	27·18
11	27·30	28·05
12	28·10	28·88

In practice, long shafts are scarcely ever entirely free from transverse strains; however, in the parts of long lines which have no pulleys or gears, with the couplings near the bearings, the interval

between the bearings may approach the distances given in the preceding table. Near the extremities of a line, the distances between the bearings should be less than are given in the table. The last space should not exceed sixty per cent. of the distance there given, the deflection in that space being much greater than in other parts of the line. In shafts moving with high velocities, it will usually be necessary to shorten the distances between the bearings, as given in the table, in order to obtain sufficient bearing surface to prevent heating.

In factories and workshops, power is usually taken off from the lines of shafting, at many points, by pulleys and belts, by means of which the machinery is operated. When the machines to be driven are below the shaft, there is a transverse strain on the shaft, due to the weight of the pulley and tension of the belt, which is in addition to the transverse strain due to the weight of the shaft itself. Sometimes the power is taken off horizontally on one side, in which case the tension of the belt produces a horizontal transverse strain; and the weight of the pulley acts with the weight of the shaft, to produce a vertical transverse strain. Frequently the machinery to be driven is placed above the floor to which the shaft is hung in the story below; in this case the transverse strain produced by the tension of the belt is in the opposite direction to that produced by the weight of the pulley and shaft. Sometimes power is taken off in all these directions, from the part of a shaft between two adjacent bearings. To transmit the same power, the necessary tension of a belt diminishes in proportion to its velocity; consequently, with pulleys of the same diameter, the transverse strain will diminish in the same ratio as the velocity of the shaft increases. In cotton and woollen factories with wooden floors, the bearings are usually hung on the beams, which are usually about eight feet apart; and a minimum size of shafting is adopted for the different classes of machinery which has been determined by experience as the least that will withstand the transverse strain. This minimum is adopted independently of the size required to withstand the torsional strain due to the power transmitted; if this requires a larger diameter than the minimum, the larger diameter is, of course, adopted. In some of the large cotton factories in this neighborhood, in which the bearings are about eight feet apart, a minimum diameter of $1\frac{7}{8}$ inch was formerly adopted for the lines of shafting driving looms. In some mills this is still retained, in others $2\frac{1}{8}$ inches and $2\frac{3}{16}$ inches have been substituted.

In the same mills, the minimum size of shafts driving spinning machinery, is from $2\frac{1}{8}$ to $2\frac{11}{16}$ inches. In very long lines of small shafting, fly-wheels are put on at intervals, to diminish the vibratory action due to the irregularities in the torsional strain.

We can deduce from formula (1) the *breaking power*, or, in other words, the power which, being transmitted by a shaft, will produce a torsional strain upon it equal to its total resistance to that force.

Put p = the breaking power, in horse-powers of 33,000 foot-pounds,

N = the number of revolutions of the shaft per minute.

$$p = \frac{2\pi \text{R N W}}{12 \times 33000},$$

from which we deduce,

$$\text{W R} = \frac{12 \times 33000 p}{2\pi \text{N}}.$$

Substituting this value in (1), we find,

$$p = \frac{\pi^2 \text{N} d^3 \text{T}}{8 \times 33000 \times 12} = 0{\cdot}000003115 \text{N} d^3 \text{T}, \quad . \quad . \quad (8.)$$

Substituting the values of T, adopted above for iron and steel, we have

For wrought iron, $p = 0{\cdot}1558 \text{N} d^3$, ... (9.)

" steel, $p = 0{\cdot}2492 \text{N} d^3$, ... (10.)

" cast iron, $p = 0{\cdot}0935 \text{N} d^3$, ... (11.)

A formula for the wrought iron shafts of prime movers and other other shafts of the same material, subject to the action of gears, which I have adopted in numerous cases in practice during the last twenty years, and found to give an ample margin of strength, is

$$d = \sqrt[3]{\frac{100 \text{P}}{\text{N}}}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (12,)$$

in which P = the power transmitted, and from which we deduce

$$\text{P} = 0{\cdot}01 \text{N} d^3, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (13.)$$

For simply transmitting power, the formula I have used is

$$d = \sqrt[3]{\frac{50 \text{P}}{\text{N}}}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (14,)$$

from which we deduce $\text{P} = 0{\cdot}02 \text{N} d^3$, ... (15.)

Comparing formulas (9) with (12) and (13), and also with (14) and (15), it will be seen that the formulas (12) and (13), used for shafts for prime movers, give a strength 15·58 times the breaking power; and the formulas (14) and (15), for shafts simply transmitting power, give a strength 7·79 times the breaking power.

In applying the rules for the strength of materials to constructions in which there is no movement, it is usual to make the computed strength from three to five times the breaking strain. Bodies in rapid motion, however, usually require a greater margin of strength, in order to provide for the tendency to vibration. In cases where shafting for simply transmitting power, is very accurately finished and firmly supported by bearings at short intervals, an excess of strength two-thirds of that given by formulas (14), (19) and (23) will undoubtedly suffice. In ordinary cases, however, the strength given by these formulas should be adopted.

It must be understood that the shafts to which formulas (12) and (13) are applied, are supported by bearings sufficiently near to each other to guard against the transverse strain caused by the prime mover or gear.

To find formulas for steel shafts of the same strength as those for wrought iron, we have for prime movers $p = 15{\cdot}58\,\text{P}$; substituting this value of p in (10), we have

$$\text{P} = 0{\cdot}016\,\text{N}d^3, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (16,)$$

from which we deduce

$$d = \sqrt[3]{\frac{62{\cdot}5\,\text{P}}{\text{N}}}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (17.)$$

Similarly, we find for steel shafts for simply transmitting power,

$$\text{P} = 0{\cdot}032\,\text{N}d^3, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (18,)$$

and

$$d = \sqrt[3]{\frac{31{\cdot}25\,\text{P}}{\text{N}}}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (19.)$$

Similarly for cast iron, we find for prime movers,

$$\text{P} = 0{\cdot}006\,\text{N}d^3, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (20.)$$

$$d = \sqrt[3]{\frac{167\,\text{P}}{\text{N}}}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (21.)$$

For simply transmitting power,

$$\text{P} = 0{\cdot}012\,\text{N}d^3, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (22,)$$

$$d = \sqrt[3]{\frac{83\,\text{P}}{\text{N}}}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (23.)$$

The following table gives the power which can be safely carried by shafts making one hundred revolutions per minute. The power which can be carried by the same shafts at any other velocity, may be found by the following simple rule:

Multiply the power given in the table, by the number of revolutions made by the shaft per minute; divide the product by one hundred; the quotient will be the power which can be safely carried.

DIAMETER IN INCHES.	Horse-power which can be safely carried by shafts for prime movers and gears, well supported by bearings, and making 100 revolutions per minute; if of			Horse-power which can be safely transmitted by shafts making 100 revolutions per minute, in which the transverse strain, if any, need not be considered; if of		
	Wrought iron, computed by formula (13)	Steel, computed by formula (16)	Cast Iron, computed by formula (20)	Wrought Iron, computed by formula (15)	Steel, computed by formula (18)	Cast Iron, computed by formula (22)
1·00	1·00	1·60	0·60	2 00	3·20	1·20
1·25	1·95	3·12	1·17	3·90	6·24	2·34
1·50	3·37	5 39	2·03	6·74	10·78	4·06
1·75	5·36	8·58	3·22	10 72	17·16	6·44
2·00	8·00	12·80	4·80	16·00	25·60	9·60
2·25	11·39	18·22	6·83	22·78	36·44	13·66
2·50	15·62	24·99	9·37	31·24	49·98	18·74
2·75	20·80	33·28	12·48	41·60	66·56	24·96
3·00	27·00	43·20	16·20	54·00	86·40	32·40
3·25	34·33	54·93	20·60	68·66	109·86	41·20
3·50	42·87	68·59	25·72	85 74	137·18	51.44
3·75	52·73	84·37	31·64	105·46	168·74	63·28
4·00	64·00	102·40	38·40	128 00	204.80	76·80
4·25	76·77	122·83	46·06	153·54	245·66	92·12
4·50	91·12	145·79	54·67	182·24	291·58	109·34
4·75	107·17	171·47	64·30	214·34	342·94	128·60
5·00	125·00	200·00	75·00	250 00	400·00	150·00
5·25	144·70	231·52	86·82	289·40	463·04	173·64
5·50	166·37	266·19	99 82	332.74	532·38	199·64
5·75	190·11	304·18	114·06	380·22	608·36	228·12
6·00	216·00	345·60	129·60	432·00	691·20	259·20
6·25	244·14	390·62	146·49	488·28	781·24	292·98
6·50	274·62	439·39	164·78	549·24	878·78	329·56
6·75	307·55	492·08	184·53	615·10	984·16	369·06
7·00	343·00	548·80	205·80	686·00	1097·60	411·60
7·25	381·08	609·73	228·65	762·16	1219·46	457·30
7·50	421·87	674·99	253·13	843·74	1349·98	506·26
7·75	465·48	744·77	279·29	930·96	1489·54	558·58
8·00	512·00	819·20	307·20	1024·00	1638·40	614 40
8·25	561·52	898·43	336·91	1123·04	1796·86	673·82
8·50	614·12	982·59	368·47	1228·24	1965·18	736·94
8·75	669·92	1071·87	401·95	1339·84	2143·74	803·90
9.00	729·00	1166·40	437·40	1458·00	2332·80	874·80
9·25	791·45	1266·32	474·87	1582·90	2532·64	949·74
9·50	857·37	1371·79	514·43	1714·74	2743·58	1028 86
9·75	926·86	1482·98	556·12	1853·72	2965·96	1112·24
10.00	1000 00	1600·00	600·00	2000 00	3200·00	1200·00

Comparing formulas (11) and (19), it will be seen that the diameters of shafts of wrought iron and steel, to transmit the same power, are in the ratio of the cube root of 50 to the cube root of 31·25, or as 1 to 0·855. The weights of the shafts will be as the squares of the diameters, or as 1 to 0·731. The power required to overcome the friction of the shafts in their bearings, assuming that the co-efficient of friction is the same for wrought iron and steel, will be as the products of the weights into the velocities of the rubbing surfaces. The number of revolutions in a given time being the same in both, the velocities of the rubbing surfaces will be as the diameters; and the weights will be as the squares of the diameters; the power required to overcome the friction will therefore be as the cubes of the diameters, or as 1 to 0·625. That is to say, the power which must be expended to overcome the friction of a steel shaft is five-eighths of that required to overcome the friction of a wrought iron shaft of equal strength.

The superiority of steel to resist transversal strain is much less than to resist torsional strain. The relative diameters of wrought iron and steel shafts, to resist equal transverse strains, exclusive of their own weights, are inversely as the fourth roots of the respective values of E, or as $\left(\frac{1}{3500000}\right)^{\frac{1}{4}}$ to $\left(\frac{1}{3800000}\right)^{\frac{1}{4}}$, or as 1 to 0·98. That is to say, steel shafts, to offer the same resistance to external transverse strains, may be two per cent. less in diameter than wrought iron shafts. The weights of such steel shafts will be about four per cent. less than the weights of wrought iron shafts of equal stiffness; and the power required to overcome the friction of the bearings will be about 6 per cent. less.

Lowell Mass., May 4, 1867.

(Continued from page 304.)

THE NEW YORK "CENTRAL PARK."

By William H. Grant, Superintending Engineer.

Should such an amount of rain fall at a time when the grounds were covered with a considerable body of snow, and the grounds not frozen, the accumulation of water might so much surpass the capacity of the gutters and drains, as to cause the gullying of the roads and grounds. But the simultaneous occurrence of such contingencies,

although possible, is not to be regarded as so probable as to cause very great apprehension, or to justify the construction of works on a scale that would be fully adapted to meet it. The drainage system for the roads of the Park, adapted as before stated, to a rain-fall of two inches in depth in one hour, is believed to possess about the maximum capacity that is reasonably practicable or desirable for such purposes under similar circumstances. It is on a somewhat larger scale than is generally adopted for city drainge, but if any doubts were remaining upon the subject, they would not be on the side of a reduction of the capacity.

Before describing the details of the drainage works pertaining specially to the roads, the following description of the connected and more extensive system of surface-drainage of the Park will not be out of place.

* The larger drainage areas of the Park have, besides the principal basins and depressions into which the water descends, other subordinate depressions and irregularities of surface, of various extent, through which the drainage water must pass, and which would form pools in many cases during rains, if proper arrangements were not made for discharging the water. There are also districts of ground in which the natural water-courses have been unavoidably obstructed by the works of the Park, forming artificial basins, which would be liable to become ponds at times of excessive drainage, if ample outlets were not provided.

Special attention has been given to all such cases, to prevent the lodgment of water. Under-drains of ample capacity have been laid, and the water admitted to them by inlets with grated covers, or where practicable, natural depressions have been modified in extent, and the ground so shaped as to give them outlets on the surface. In some instances, to guard against contingencies, double outlets are made, one communicating with a separate drain from the other, or communicating with the same drain or sewer, at a different point, where the capacity is enlarged.

Experience has shown that it is not safe to rely upon mere agricultural drains, however perfect they may be, to absorb and carry off sudden accumulations of water from any considerable area of depressed ground. Such drains act by a slow process of percolation under the most favorable circumstances, and are liable to become entirely inoperative for surface-drainage at times when they are much needed; as, for instance, when the ground is temporarily and lightly frozen, or when it has been frozen to the greatest depth, and is gradually thawing out, the lowest portion of the frozen stratum remaining unaffected and impervious for a considerable length of time. At

* From Report of Superintending Engineer of January 1, 1862.

such times, standing water on the surface for a longer or shorter period, must result from a thaw of snow or from rain, and if no other drainage ensues, lawn grass and shrubbery that might be submerged would be likely to receive serious injury.

The surface and under-drains for the grounds at large, connect with the road-drains, and together make up a common system.

Besides the drains here alluded to, that lie below the surface, other drains, water channels, paved gutters and catch-water drains, or "sod-gutters," lying upon the surface, form a part of the system.

Where drainage water is brought to the roads from adjacent higher ground, it is generally intercepted by sod-gutters in the manner hereafter described under the head of *walks*.

The drainage of the roads is received into the under-drains below, through strongly grated inlets in the road-gutters. [Plate II.] The wider roads have under-drains to each gutter; the narrower roads have but one under drain. In the latter case, branch drains crossing the road connect the gutter inlets that are on the side of the road opposite to the main drains, with these drains. The inlets are placed from two hundred to five hundred and fifty feet apart (generally two hundred to three hundred feet apart), and are in all cases constructed with silt basins at the bottom, to catch and retain any substances that would otherwise be carried into the drains.

The road-drains and adjoining sod-gutters discharge, at various convenient points, into larger under-drains or sewers, and thence the water is conducted to the ponds or to the drainage outlets of the Park.

The road-drains are variously composed of stone or earthenware, vitrified and glazed pipes, cement pipes and brick sewers. The vitrified glazed pipes have been the most extensively used. Cement pipes were introduced upon the Park after the work had been considerably advanced; they are of quite recent manufacture in this country, and were recommended by their cheapness as compared with the earthen pipe. They are made of hydraulic cement and sand and gravel, intermixed in the form of a mortar, and are moulded with accuracy, and are submitted to pressure during the process, by means of machinery. When thoroughly made of the best materials, they possess the necessary strength and other qualities required for drain-pipe. They cannot be safely used, however, without being first subjected to such tests as will prove the indurating and hydraulic properties of the cement, which latter material is the important ingredient in their composition. They are not quite as perfect in their operation in conveying and discharging water as the earthen *glazed* pipes, as the latter pipes, from the superior smoothness of their interiors, cause less friction and retardation of the water, but they are superior to brick sewers in this respect.

In the use of the earthen pipes, they were found to be cheaper than brick drains, for all the smaller sizes of twelve inches and under. The cement pipes, as compared with brick, are ordinarily cheaper than brick, up to sizes of about twenty-four inches, which are the largest that have been used on the Park.

Previous to arranging and laying down these pipes along the roads, the areas of drainage surface for the different widths of roads were computed, together with such exterior drainage as was immediately connected with the roads, and the sizes of the pipes were graduated to receive the accumulated water entering at successive points from the summit to the foot of each descent in the line of the roads, or to such points where the pipes, from the necessary increase of capacity, give place to larger sewers that conduct the drainage in various directions, to the Park ponds or to the drainage outlets of the Park.

A specification of the manner of laying these drain pipes will be given hereafter.

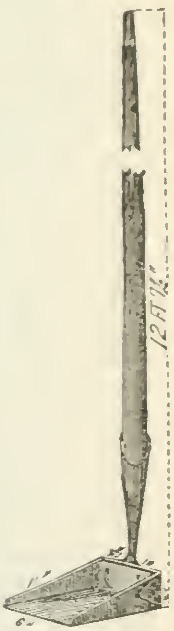
SILT BASINS.—A. B. & C. D., PLATE II.

These basins, as before stated, are constructed in connection with the road-gutters, at distances of two hundred feet to five hundred and fifty feet apart, along each gutter. They are adapted in capacity to receiving and retaining such quantity of silt, mud or road detritus, as is likely, under ordinary circumstances, to be discharged into them during a heavy rain of the duration of twenty-four hours. They are very seldom filled in that space of time, and only hitherto in exceptional cases arising from the washing of newly made slopes adjoining the road, or of gravel from the road, that had been freshly deposited and not rolled or compacted before the occurrence of a heavy shower. They will hold about a cart load of silt below the level of the outlet or discharge pipe. Their object is to prevent silt or other substances from being carried into the drain-pipes and obstructing their flow.* The bottom of the basins is generally five feet below the surface of the road-gutter, the outlet or connecting pipe between the basin and main road drain being about three feet below the gutter. The connecting pipe has usually a descent, before entering the main drain, of a few inches, to obviate any liability of

* They also serve a good purpose in partially relieving the drainage water of the roads from sediment and impurities before it reaches the filters and depositing basins that pass the drainage water into the Park ponds.

the larger volume of water flowing through the main, being diverted into the basin. Some of the basins first constructed, were inserted directly in the line of the main drains, the latter entering and discharging in the basin on one side, and passing out on the other. [Plate I., Telford road.] This method was considered objectionable on account of its checking the flow of water through the pipes, and also for the reason that the agitation of the water in the basin by the passing current, tended to prevent the desired deposit of sediment. The preferable plan of keeping the main pipes separate and a few feet distant from the basins, and connecting them by a branch-pipe, has been generally adopted. [Plate I, gravel road.] The mains follow as nearly as practicable, the lines of the road-gutters, turning aside at the points where they pass the silt basins, and occasionally diverging to the right or left, to avoid embedded boulders or projecting portions of rock.

Fig. 1.



The silt basins are constructed of hard, thoroughly burnt brick, laid closely and tightly in hydraulic mortar; the upper part above the level of the outlet pipe, is covered over, except the aperture communicating with the gutter, with strong flags or flat stones. Upon this covering is built up the neck of the basin that supports the gutter grating. The grating is twelve and a half inches wide and twenty-four inches long, the bars being two inches deep, and is strongly made of cast iron, and fitted like a lid to a cast iron curb or box that is supported by, and forms a part of, the neck or inlet of the basin.* The gutter stones are joined up around the curb, the surface of the gutter coinciding with the top of the grating. The grating is easily lifted off and replaced in cleaning out the basin. A small scoop of sheet iron attached to the end of a pole ten to twelve feet long, (Fig. 1,) is used in removing the silt, which is first deposited in a heap on the road near the gutter, and when sufficiently dry is hauled away.

The basins are examined from time to time, and the directions are that they be cleaned out in all cases, before the deposits accumulate

* The gratings weigh eighty-eight and a half pounds; the curbs weigh ninety-three pounds each

to such an extent as to endanger their being carried into the drain-pipes. The water standing in the basins, usually up to the level of the outlet pipe, is protected, by the depth below the surface of the ground, the contracted aperture, and the grating covering the top, from freezing in winter, so as to injure the masonry of the walls. The following remarks on the general drainage of the Park will not be without interest in closing this description of road-drainage.

*A recapitulation of all the works that have now been constructed for superficial and sub-drainage, and for supplying the Park with water, consisting of sewers, pipes and tile drains, and the iron and cement water pipes, shows an aggregate linear extent of 398,764 feet, or 75½ miles. The completion of the several systems will make this aggregate about 110 miles.

It is worthy of remark, that this extent of work, which performs so essential a part in the successful improvement of the Park and in developing its attractions, is wholly under ground and hidden from observation.

The statement of the aggregate linear measurement, together with the brief descriptions that have been given of some of the leading parts, will suffice to give a general knowledge of the scope of the work and of the amount of labor involved; but it is only by a reference to the working maps and plans in detail, that an adequate idea can be formed of the entire arrangement, adaptation and working of the respective systems.

The large area of the Park which is broken into undulations of all degrees, from precipitous to long gentle slopes, receives the heaviest showers of summer, and the water, instead of accumulating in rushing streams and gullying the grounds, quietly and harmlessly disappears below the surface, and is gathered into the veins and arteries of the drainage systems, and passed off to supply the ponds, or is discharged from the Park in the same unperceived manner. When a shower has subsided, its inconvenient effects soon disappear, leaving undisturbed lawns, and the roads and walks comparatively dry and fit for immediate use. The Croton water, at all points where it is desired, appears at command, or ascends in fountains at the appointed places; but the 110 miles of channels and the various connected works through which all this is performed, are unseen, and show no evidence of the connection that exists between the effect and the cause.

The direct practical results alone, are all that will arrest the attention of visitors or ordinary observers. Other works of the Park exhibit to the view their various purposes of utility and ornament, in more or less detail, and are accessible for inspection and repairs; but these spread out beneath the surface their extended reticulations,

* From Report of January 1, 1862.

and perform their principal functions silently and unseen, and can be approached and examined only by indirect means.

These facts give to this class of works a special interest, and show the necessity of special care and attention being given to works so situated, to maintain them in successful operation.

(To be continued.)

From the London Mechanic's Magazine, April, 1867

STEEL WIRE.

Steel wire is now chiefly used in the manufacture of needles, fish-hooks, springs, music-strings, small tools, umbrella frames, crinolines, and ropes, both for the home and foreign trades. Its application to ropes and cables is of very recent date, and is entirely owing to the success of Mr. Horsfall's invention; ordinary steel wire being manifestly useless for the purpose, and absolutely dangerous. As soon as it became known that a steel wire could be produced which combined all the advantages of lightness with hardness and extreme tenacity, it obtained a considerable share of popular favor; and, although it has been introduced within the past seven years, it has already attained a high position in the estimation of consumers, and, as prejudice is more and more overcome, must some day attract still greater attention. The steel wire rope is now used at many collieries; and is highly valued in deep pits especially, where the light weight of the rope is of such importance, both in connection with the safety and economy of the working. For railway inclines, lifts, and even ship's rigging, the same reasons are rapidly bringing it into use. Not the least important of the various mechanical inventions of the present day, which the introduction of a suitable quality of steel wire has materially assisted in perfecting, is the application of steam machinery to agriculture. The late Mr. Fowler has more than once declared "that he owed the success of his plough to the introduction of Webster and Horsfall's steel wire." But the most important use to which this wire has yet been adapted, and the one which is now exciting such universal interest, is the manufacture of submarine telegraph cables. During the past five years, large quantities have been used for cables in the Mediterranean; and lately, as is well known, it has formed an important and successful portion of the Atlantic telegraph cable. The manufacturer of this wire, in its various departments, kept nearly 250 hands employed for eleven months, the total quantity supplied being over 30,000 miles in No. 13, I. W. G. (=·095). We take the foregoing from Mr. Timmins's "Birmingham and the Midland Hardware District."

Mechanics, Physics and Chemistry.

LECTURES ON VENTILATION.

Delivered before the Franklin Institute, by L. W. Leeds, Esq.

LECTURE II.—(Continued from page 328.)

It is in connection with this system of heating by circulating warm air, that the erroneous views in relation to ventilation generally entertained by the public, produce the most injurious effects.

The special points to be borne in mind in considering this subject are that, when in motion, warmer air rises and colder air falls; but when at rest, the stratums of air of different temperatures arrange themselves horizontally.

One other thing: we must remember *temperature* has nothing to do with the purity or impurity of the air. The pure air entering a room is *sometimes* colder than the average temperature of the room, and falls to the floor, forcing the warmer, and, in that case, fouler air to the upper part of the room.

But frequently, in winter, the fresh air enters *warmer* than the average temperature of the room, and *rises to the ceiling*, and flows across the room above the colder and fouler air that has been longer in the room. You must not forget the experiments in our first lecture, showing that the breath in an ordinary room, of a temperature of 70°, fell to the floor instead of rising to the ceiling. I propose illustrating this part of our subject, by using a little glass room to show the movements of air of different temperatures. We can either use air of different temperatures, showing the motion of the various currents by a little smoke; or, as the laws governing the circulation of liquids of different densities are so similar, and by the use of a little coloring matter will express to an audience of this kind more promptly and clearly the ideas which we wish to convey, we therefore propose using the different colored liquids this evening.

The colors, of course, have nothing to do with the densities, but are merely used as a convenient method of designation; the red representing heat or lightness, and blue coldness or density.

The room is now filled with clear water, slightly blue, to represent cold, and a little salt, which makes it a little more dense than fresh water. Now, I will let in a little fresh water, colored red by cochineal,

Fig. 1

Fig. 2.

P. S. Duval Son & Co. Lith. Phil.

Fig. 3.

to represent heat, and by making a similar opening on the opposite side for its escape, you will be able readily to see in what direction it moves. There, see it entering—see how it flows directly across the top of the room, and escapes at the opening on the opposite side. You see it disturbs the lower and colder parts of the room but very little. Thus a large flow of pure fresh warm air might be going through a room all day, and be entirely wasted, neither warming nor ventilating it. Fortunately, there are but few buildings arranged in quite so absurd a manner as this. I believe it was tried in the House of Lords, on the erection of the new Houses of Parliament, but, of course, failed. I think they still adhere to it in some of the wards of some Insane Asylums, where they depend, I suppose, upon the excitement of the patients to keep themselves warm and the air stirred up. I also noticed this arrangement in a new building just being finished, a few years since, at Yale College. The architects of that building had probably been impressed with the dreadful effects upon the health of students of the air from our ordinary hot air furnaces, and thought they would avoid all such danger. I think, however, it would have answered their purpose just as well, and been much more economical, to have placed the furnaces at the coal mines, and saved the trouble and expense of carrying the coal so far. I expect they have made other arrangements, probably, by this time.

We will now close the opening at the top for the *inlet* of the fresh warmed air, and open a valve, so as to allow it to flow in at the bottom. We will allow the opening at the top for the *outlet* of the foul(?) air to remain as before, (see figure one, lithograph plates.) This is quite an improvement; it agitates the air much more than the other, and by going and standing directly over the register, you can always get in the current of fresh warm air. But you see to what a very small portion of the room the heated air is confined, rising in one perpendicular column directly to the ceiling, and then flowing horizontally along the ceiling to the outlet. How little it disturbs the main portions of the room, especially the lower and occupied part.

I hope you will notice that this illustrates the popular notions of ventilation. I suppose three-fourths of all the buildings in this country, or in Europe, where any attempts at artificial ventilation have been made, are thus arranged. Dr. Franklin knew better, and made a much more perfect arrangement than this. But we are probably mostly indebted to that very able and enthusiastic advocate of ventilation, Dr. Reid, for this popular opinion. The whole of the plan

that he advocated is but little understood by the public. He assumed that the natural warmth of the body created an ascending current around us, and caused the breath to rise towards the ceiling, and consequently, in all artificial arrangements, it was best to endeavor to imitate this natural movement of the air. And to overcome the great practical difficulty we see here exhibited, of the fresh warm air flowing through the room, and disturbing so small a portion of it, he proposed making the whole floor one register, and thus have an ascending column over the entire room. For this purpose, the floors in the Houses of Parliament were perforated by hundreds of thousands of gimlet holes, and the whole cellar made a hot air chamber. This was a magnificent idea, and, I believe, in some few instances, where fully carried out, has given a good degree of satisfaction; but it is always difficult to adjust the opening and the pressure so as to cause an even flow over so large a surface, and at the same time to be so gentle as not to be offensive to those with whom it comes in contact. But this thorough diffusion cannot be conveniently applied in one case in one thousand. It must necessarily be always very extravagant, as it will always require a great amount of air to insure a thorough circulation through all parts of the room. I wish, therefore, most emphatically, to condemn all systems relying upon openings in the ceiling for the escape of the foul air while depending upon the circulation of warmed air for obtaining the necessary additional warmth. In practice they are universally closed in winter, for the purpose of keeping warm, and as such openings have been so generally considered the *only* ones necessary for the proper ventilation of a room, and as they had to be shut in winter, just when artificial ventilation was most necessary, it has created a very strong prejudice in the popular mind against all ventilation.

The result of the advocacy of these impracticable theories by so many able and learned men, (most physicians writing upon this subject have adopted them,) has been the shutting up of many thousands and tens of thousands, till they have smothered to death.

The ravages of consumption and the excessive infantile mortality, and the many diseases resulting from foul air poisons, are in a great measure due to the general advocacy of these false theories. As I have before said, Dr. Franklin knew better than this, and had we been contented to have followed his simple practical advice, instead of being dazzled by the splendid theories of others, thousands of our friends would now be with us who died long since for the want of fresh air.

Now, let us see how Dr. Franklin says a room ought to be ventilated, He says, "the fresh air entering, becoming warmed and specifically lighter, is forced out into the rooms, rises by the mantel-piece to the ceiling, and spreads all over the top of the room, whence, being crowded down gradually by the stream of newly warmed air that follows and rises above it, the whole room becomes in a short time equally warmed." This is the principle upon which his celebrated Franklin stove was arranged. Now, let us see if we can arrange our little glass house so as to illustrate this. We will first fill it with what we call our cold air, and will close the outlet at the top, and take out the fire-board. Now, as I let in the warm fresh air, it rises immediately to the top, as before, and flows across the ceiling, but as it cannot escape there, it forces the cold air down, and causes it to flow out at the fire-place. See how quickly the whole room is filled with the fresh warmed air. Ah! I see I am a little too fast—there appears to be a stratum of a foot or two, lying on the floor, that is not disturbed yet. It flows out at the top of the fire-place, and therefore does not reach to the floor. This is frequently the cause of cold feet and much discomfort. We will make the opening directly at the floor, (see Fig. 2, Lithograph plate,) and that forces all the cold air out, warming and ventilating the whole room. Here is the whole problem solved in the most beautiful and simple manner. And you may exclaim, as you see the simplicity and perfect working of this, how came any one ever to think of anything else.

Here, again, you see the value of that most excellent and valuable of household arrangements, the open *fire-place;* even without the fire it serves a most important purpose.

We must not forget, however, that there are other circumstances in which it will not do to depend on the fire place alone for ventilation. Now, by leaving the fire-place open, just as it is, and the room full of warm air, we will simply change the *condition* of the air supplied, and allow cold air to flow in at the bottom instead of top. (See Fig. 3.) There, you see the fresh *cold* air simply falls to the bottom and flows across the floor, without disturbing the upper part of the room at all. It acts just the reverse of the hot air let in and taken out at the top of the room. When you are ventilating a room by *opening a window*, therefore, it is often necessary to open it at the top; but remember when you are ventilating by doors and windows, (which are the great natural ventilators,) *they* are an entire substitute for flues—flues are then of no account. All *windows*, therefore, ought to be

made to *lower from the top*, and all ventilating *flues* ought to be made to *open at the bottom* of the room.

I have noticed another very interesting feature in regard to the circulation of liquids of different densities; for instance, suppose we fill our little room half full with salt water, and the remainder with fresh water, we will now apply a spirit lamp to the bottom of the room. As the salt water becomes heated it rises rapidly, but not to the top of the room, but only half-way, or to the top of the denser liquid, and then spreads across the room horizontally. Thus the salt water will keep up a rapid circulation, and may be heated almost to a boiling temperature *underneath* of, and without heating or disturbing, the cold fresh water *above*. I have tried some very beautiful experiments of this kind with a number of liquids of different densities in the same vessel. Gases of different densities are probably influenced in a similar manner by the application of heat. And here we see the value of that beautiful law of the diffusion of gases, by which each gas, no matter what its density, is equally diffused in all directions through the other gases, independent of temperature.

I desire to call your attention this evening to one other distinct system of heating—I mean that very convenient, economical, cleanly and very FASHIONABLE system of heating by direct radiation from steam-pipes.

As steam has become such a common article in all large buildings, both for power and as a convenient means of distributing heat, most large buildings are thus heated, and as a perfectly air-tight building can be very easily heated thus, and as most persons are too ignorant or too careless to provide a separate and distinct supply of fresh air simply for ventilation alone, the consequence is, that this system, thus so shamefully abused, is probably drying up more talent and killing more business men in our cities than any other system in existence. This applies especially to the editorial rooms of nearly every one of our leading newspapers and publishing houses. They use steam for driving their beautiful printing presses, and the heating and ventilation, or rather, the entire want of ventilation, in their offices, would indicate that they thought that the same power that drove their presses, to do the printing so nicely, was entirely sufficient to drive them to write the original articles for the printer, and that they had no more need of *fresh air* than their presses.

You may think that I am certainly mistaken that so intelligent a class of the community, who are building such splendid fire-proof build-

ings, such perfect palaces of iron and stone and marble, as our newspaper establishments are building in New York, Philadelphia and other large cities, would never make such a blunder as to omit providing the most abundant supply of pure, fresh air to every employé in their establishment, and at all times, both in summer and winter.

Should there be any one present thus doubtful, I wish he would undertake to get any one of our enterprising newspaper establishments to publish in their paper an accurate intelligible account of their system of ventilation, illustrating clearly the known quantity of pure, fresh air delivered within using distance of each one of the editors and employés.

I think he would soon come to the same conclusion I have, that the advice of the minister to his congregation would be very applicable to them—"Always do as I *say*, but never do as I *do*."

(To be continued.)

LECTURES ON MINERALOGY.

By Theodore D. Rand.

LECTURE I.

CLASSIFICATION, NOMENCLATURE, CRYSTALLOGRAPHY, CHEMICAL COMPOSITION, COLOR, HARDNESS, SPECIFIC GRAVITY.

Mineralogy and *Geology* are so allied that many persons regard them as almost identical; but the distinction is very clear, and may be given in a few words.

Geology studies the *rock masses* which form the crust of our globe. Mineralogy studies the *minerals* which form these *rock masses*. The whole number of these minerals is not much over six hundred, but notwithstanding this, few sciences have suffered more for want of a judicious, systematic nomenclature and classification. The object of nomenclature and classification is not to draw supposed natural lines dividing minerals, for such nature does not draw. Her plan admits, neither in the mineral. vegetable nor animal kingdom, of well and clearly defined lines, but from the animalculæ, and even from the vegetable, to man a ladder is found, the steps of which are almost in contact. By this, I do not mean to encourage the unscientific development theory, that the higher organisms have sprung from the lower, (for no evidence of such has ever been found,) but simply that the

fact which gave plausibility to the Darwinian theory, that there are closely connecting links between every division which we may make, prevails in mineralogy, as in all other sciences.

The real object, therefore, of all classification should be the arrangement of the species in that order, and in such groups, as shall most aid the memory in studying their peculiarities, and shall, as far as possible, place species having strongly marked similar characteristics, together. In Botany, Zoology, Conchology, &c., the vast number of species, and their various common names, have rendered it necessary to give to every genus a name, to which is added another for each species in that genus, each name being, as far as possible, founded upon some characteristic of the species. The comparatively few mineral species and the comparatively few common names render a classification of this kind cumbersome, and productive of greater evils than those we would avoid.

Professor Dana, abandoning the pre-existing arrangements, offered, in his edition of 1857, a classification of this kind, giving new double Latin names to all minerals, and subdividing minerals into classes, orders, genera and species, but it found no favor with mineralogists, and was abandoned by him in his third edition, in which he says: "There are errors in its very foundation, which make it false to nature in its most essential points, and in view of the character of these errors, we are willing it should be considered a relic of the past."

Based upon the system of Mohs, Werner, Brochant and others, arose a classification by which, probably, the majority of cabinets are arranged, and which is that used by Dana in his third edition. This divides minerals into seven classes, by chemical composition. Four of these contain, in the aggregate, but thirty-five species—the remaining three are subdivided according to their chemical bases, two of them into six groups, the third (metallic) into fifteen. Inasmuch as the base in any mineral is generally characteristic, easily ascertained and remembered, and especially in metallic species those of the same bases occur naturally together, this is a most convenient arrangement for ready reference and memory. There are, it is true, objections to it, probably the strongest being, that many bases, being isomorphous, may be indefinitely substituted one for the other, but this objection will be found more apparent than real, for many of the isomorphous bases are grouped together, as for example, lime and magnesia.

In Professor Dana's fourth edition, he has arranged the species after a strictly chemical crystallographic system, giving prominence chemically to the electro negative, or the acid of the compound. There are many advantages in this system. It is perhaps the most scientific arrangement, but it would be most difficult of acquisition, there being few of the aids to memory of the former system, and there being but one hundred and sixteen groups; but the gravest objection is, that it brings in juxtaposition the most dissimilar minerals and separates those closely allied. Thus, periclase and red copper, carbonic acid and quartz, calamine and prehnite, alunogen and brochantite, oxide of zinc and water, are placed in juxtaposition, while metallic iron, specular iron, magnetic iron, brown hematite and gœthite, almost identical in chemical composition, varying but in content of oxygen and water, and naturally associated, are distributed through four grand divisions and five groups. The ordinary well known ores of copper are similarly distributed through six grand divisions and seven groups.

The following is the classification by bases above referred to, slightly altered from that of Professor Dana, by making divisions of some of his subdivisions.

I. Nitrogen, Hydrogen.
II. Carbon, Boron.
III. Sulphur Selenium.
IV. Salts, non-metallic, not silicates, (Hydrates, Sulphates, Carbonates, Phosphates, &c.)
A. Salts of Ammonia.
B. " " Potassa and Soda.
C. " " Baryta and Strontia.
D. " " Lime and Magnesia.
E. " " Yttria, Ceria, Thoria, &c.
V. Silica and Silicates, not metallic.
A. Silica.
B. Hydrous Silicates and Boro Silicates of Lime and Magnesia.
C. Hydrous Silicates of Magnesia.
D. Anhydrous Silicates of Lime and Magnesia.
E. Hydrous Silicates of Alumina.
F. Zeolites.
G. Anhydrous Silicates of Alumina.
H. Feldspar and allied minerals.
I. Garnet do.
K. Mica do.
L. Aluminates of Magnesia.
M. Silicates of Glucina.
N. do. Zirconia, Thoria Yttria, &c.
VI. Metals and Metallic Ores.
A. Tin, Titanium, Molybdenum.
B. Titanates, Columbates, Tungstates, &c.
C. Uranium.
D. Bismuth, Tellurium, Antimony, Arsenic.

E. Chromium.
F. Iron.
  1. Sulphides.
  2. Oxides.
  3. Salts not silicates.
  4. Silicates.
G. Manganese.
  1. Sulphides.
  2. Oxides.
  3. Salts not silicates.
  4. Silicates.
H. Cobalt, Nickel.
I. Zinc, Cadmium.
K. Lead.
L. Copper.
M. Mercury.
N. Silver.
O. Platinum and associated metals.
VII. Resins, or organic compounds.

Of course, in this arrangement, the word metal is used in its popular sense.

(To be continued.)

From the London Engineering, No. 70.

PUMPING BY WATER POWER.

THE April number of *Les Annales du Génie Civil* contains a paper by M. Achard, descriptive of the water-works carried out under his direction for the supply of two suburbs of Geneva, known as Petit Saconnex and Grand Saconnex, the latter elevated 104 metres, or 341 feet, above the level of the Rhone, a little below where it leaves the Lake of Geneva. The river, here—and it is here that Bonnevard (the Prisoner of Chillon) was supposed, by a fiction of poetry, to have seen it when he spoke of the "Blue Rhone in fullest glow"—has a current sufficiently swift to work a large paddle or undershot wheel for driving pumps, and water-power pumping works have accordingly been erected by MM. Menn, Lullen & Co., engineers, of Coulouvrenière, near Geneva. These consist of a wheel, 33 feet 6 inches in diameter and 20 feet face, driving a pair of double-acting pumps, of a collective capacity of $6\frac{2}{3}$ gallons, or $13\frac{1}{3}$ gallons for the double stroke, at four times the speed of the wheel itself, the ratio of the gearing being as 4 to 1. At $2\frac{1}{4}$ revolutions of the wheel per minute, 120 gallons per minute are thus pumped. Including friction and all resistances, the pumps work against the great resistance of 472 feet of water. The usual speed of the water-wheel is, however, $1\frac{5}{8}$ turns per minute, and the corresponding head, including friction, is 380 feet.

ERECTING THE INVERTED IMAGE

IN THE MAGIC LANTERN.

By HENRY MORTON, Ph.D.

A LENS, as every one knows, inverts the image which it makes of any object; hence, in the magic lantern, we place the picture upside

down, and right for left, in order that its image on the screen may occupy a true position. This is the shortest road out of the difficulty, of course, where it can be followed; but there are many cases in which such a treatment of the subject is inadmissable. Thus, if we wish to exhibit to a large audience the manner in which tacks or iron filings are vivified by a magnet; how water assumes the spheroidal state on a heated surface; how the same fluid is caused to circulate by local changes of temperature, or is decomposed by a galvanic current, or any of the many similar experiments which may be conducted with striking effect in a lantern, we must resort to some means other than "inversion of the object" to secure an erect or right-side-up position of the image on the screen.

The desirability of some means for reaching such a result is very manifest, and the most natural first thought is to use a square prism, as described by Brewster in his Optics, page 270, where a drawing is given, curious at once for its theoretical accuracy and practical impossibility; an equilateral triangle being taken to represent a square prism, and the refracting action indicated as about eight or ten times as great as it could possibly be. Yet, viewed as a symbol or hyroglyph, this drawing, as will be shown presently, may be regarded as embodying actual results, which, if known to the author, were certainly not hinted at, and to the best of our belief, will find their first publication at this time.

A more accurate drawing of the same thing is to be found in Frick's *Physical Technics*, (an admirable work, which should be in the hands of every experimenter and manufacturer of apparatus,) page 209.

With such authority, we should have proceeded to experiment, but for the information, from one who had given much attention to lantern manipulations, that the plan had been tried and abandoned by him, in consequence of the loss of light and reduction of field which it entailed. Professor R. E. Rogers, who had gone further than we, and had made some experiments, was, we believe, deterred from further attempts by the same cause.

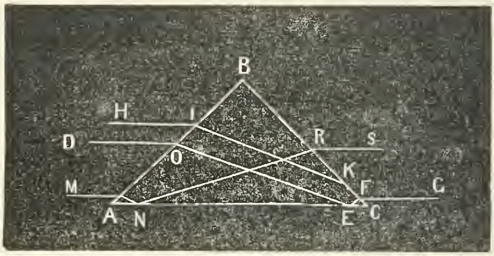
A trial, however, was at last made which satisfied us that, under proper conditions, a good result might be realized with a square prism, placed in front of the objective of an ordinary lantern.

The accompanying cut, which is drawn with some attention to accuracy of direction and angle, will show, on inspection, how the upper and under rays, D and M, change places, and thus how the inversion is corrected. In using this prism, no inclination is given to the lan-

tern. It remains directed to the screen, exactly as with the inverted image.

The loss of light experienced is not serious, so that we are able,

Fig. 1.



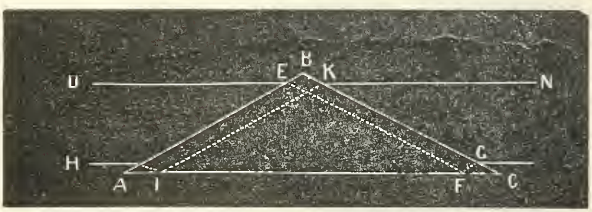
with an ordinary lantern, to cover a screen of twenty feet in diameter with a brilliant circle of light; while the contraction of field, though notable, is not of any practical inconvenience.

The only drawback was the difficulty and cost of obtaining prisms large enough, and this difficulty has been overcome by the ingenuity of Mr. Zentmayer, who has devised the excellent improvement we shall now proceed to describe.

Observing that with the square prism, only the lower portion is available, any ray above D, Fig. 1, such as H, for example, failing to strike the base and be reflected, but suffering reflection downwards at K, and so being lost, he proposed to make the prism of such a shape as is indicated in Fig. 2.

Here the angle B is calculated to equal the angle of refraction of

Fig. 2.



an horizontal ray, such as D at the surface A B, plus 90°. Under this condition, such a ray, after refraction, would be parallel to the further side, B C, and would therefore reach the base, A E, and be reflected from it, however near to the summit, B, it might strike.

The lower ray, H, would be in an equally favorable condition, as is clear from inspection of the figure.

The angle, B, is 125° 30′, A and C, of course, 27° 15′ each. It

might be thought that the great obliquity of the surface, A B, would cause a serious loss of light by reflection, but this drawback does not appear in practice.

The economy in thickness of glass required to produce a prism of given effect is decidedly very great. In fact, the ordinary optical glass, which is easily procured, answers perfectly; while for the square prism of sufficient size, it would be necessary to order blocks especially from the foreign manufacturers.

With regard to the curious *symbolism* of Brewster's drawing, we can now explain, that the rays, after refraction, were represented as proceeding in lines parallel with the faces of the prism, as in Fig. 2, though with a triangular, or even with a square prism, this was entirely impossible.

We do not wish to claim any originality in the use of a square prism, as above described, but only to call the attention of those interested, to the practicability and success of the arrangement. The form devised by Mr. Zentmayer is, however, we believe, entirely new, and certainly most efficient, and he is entitled to all the credit of its invention.

EDUCATIONAL

(Continued from page 356.)

THE MAGIC LANTERN

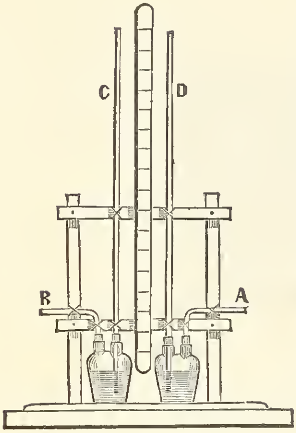
AS A MEANS OF DEMONSTRATION.

HAVING now pretty fully discussed the methods of preparing, and storing the oxygen and hydrogen gases, we will next proceed to describe the best form of jets for burning them, first, however, giving some account of a simple gauge, to indicate the pressure employed on the gases, which we have found of the greatest possible value and convenience.

A mere inspection of Fig. 8 will make this arrangement plain, almost without a description. The two bottles of two necks, such as may be obtained from chemical dealers, are blown from glass tubes, and hold about two ounces. The tubes are fitted to their necks by means of rubber corks, or short pieces of rubber hose used as corks,

and by this means a *perfectly* air-tight joint may be secured. It is well also not to make the long upright glass tubes continuous throughout; but, having inserted short pieces in the bottles, to connect these with the prolongations by short pieces of rubber hose. By this means the risk of breakage to tube or bottle is greatly diminished, and the ease of repair, should the former be fractured, is greatly increased. In practice, with much moving of the apparatus from place to place, we have never had a bottle, and but seldom a tube, broken. We need hardly say that each bottle and tube forms a gauge to a separate gas, the pair thus shown answering for the oxygen and hydrogen, in an ordinary lime light. These gauges are fastened either beneath or upon the table used for the lantern. A small three-way, or T connection being attached at A and B, the gases on their way from the reservoirs to the stop-cocks which control the jet, exert a pressure in the bottles which is measured by the rise of the water in the tubes C and D. The height of these tubes should be from twenty to twenty-four inches. A scale of paper pasted on a strip of wood, placed between the tubes, serves to indicate the pressure registered by each.

Fig. 8.



These gauges enable one to make sure of the tightness of all joints in the connected apparatus; or, if a leak occurs, readily to find its position. Thus, the jet being shut off, we bring pressure on the reservoirs, gas-bags, or the like, and then turn on the stop-cocks leading from these, for a moment, closing them at once again. The gauges then, after rising, fall slowly if all is tight, though rapidly if there is a leak. Should a leak be indicated, turn on the gas from the reservoir, a little; then, pinching the flexible connections with the hand, find where the gauge will stand when thus cut off from the reservoir, and where it will fall. Between these points will be the leak.

The Jet.

After very extended experience with jets of many forms, we have become thoroughly convinced that the best and most satisfactory, both for economy and efficiency, is the simplest.

This form is shown partly in section at Fig. 9. It consists of a slightly tapering copper tube, of about one-tenth to one-sixteenth inch internal diameter, fitted into a screw-cap which is attached to a socket, in which meet and terminate the two tubes conveying the different gases. The copper tube is battered in at the end, and then has a small hole drilled through the flattened portion, so that the outlet is of the nature of a perforation in a diaphragm. With such a jet as this (the form devised and used by Robert Grant, of New York), the light will be concentrated, intense and perfectly reliable, so long as the pressures on the different gases do not differ by more than five or six inches of water, and are moderatly heavy, (ten inches of water, or over.) With great excess of pressure on one gas, the light will, of course, be bad, and if the excess is on the oxygen, there may be a snap or explosion in the jet, after which the flame will burn inside of it, giving very little light, and, of course, tending to injure the tube. This snapping, in such a case, is not due to the form of the jet. It will happen in any one in which the gases mix, even if the interior be filled with the wire gauze or other "safety" appliances. In the simple tube, however, the accident is easily repaired, while with the more complex arrangements it is more apt to give trouble, and may even lead to some danger. Thus, if the jet of this simple sort snaps, we at once turn off the oxygen gas, or both if we please, and should feel obliged to it for calling our attention to something wrong, which was undoubtedly wasting our gas, or impairing the light. We then at once look to the pressure as indicated by the gauge, and will be pretty certain to find that adjustment is there needed. More pressure on the hydrogen is required. Should the gauge say "all right," there may yet be two other causes of trouble; a kink in the hydrogen connections, which will be shown by an immediate fall in the gauge, on opening that stop-cock to the jet; or a bad adjustment of the stop-cocks themselves: to this we come back in default of other causes.

Fig. 9.

With these simple jets, then, all will go right so long as good conditions are maintained, and if these conditions are deranged beyond a certain limit, warning will be given which will oblige us to apply the necessary correction Beyond this nothing can happen. With the free outlet furnished by the open jet, any mingling of the gases in the reservoirs is simply impossible while any light is being obtained

at the jet. If the pressures could be made so enormously unequal that one gas drove back the other, and entered its reservoir, there would be but one gas, and therefore no light, at the jet. Diffusion travels too slowly in narrow tubes to have any effect, where even a very tardy outflow is taking place.

With the so-called "safety-tubes" between the mingling of the gases and the outlet of the jet, there *may be* danger.

The great resistance which these offer to the outflow *may* enable some mingling action to go on if the supply tubes are short and large, the stop-cocks wide open, and the pressures unequal. We have yet, however, to hear of an authentic case of accident from this cause.

In one instance the jet snapped, and the retreated flame melted up the gauze and closed the jet. The stop-cocks being kept open while a new jet was being prepared, the gases, unequally loaded, mingled in one of the bags, which, on starting the new jet, gently exploded. This is the only case we have heard of in which the cause could not be traced to a badly ground dissolving stop-cock, careless mixing of gases in the same bag, or the like.

The "safety-tube," we seriously think, can afford little, if any, protection. The explosion of an oxyhydrogen mixture may occur through the best safety-tubes, on sudden relief of pressure, as has been shown by Prof. Hare and by Dr. Charles Cresson, and, on the other hand, the resistance offered by the wire gauze, and like material, is likely to do harm.

The best security is to adjust the stop-cocks of the jet in such a manner that they are neither of them more widely open than is necessary for the supply of the flame. Should the jet become overheated by the retreat of the flame, when it is not observed, it must then be cooled by a touch or two with a wet rag, or even by letting the hydrogen flow through it for a minute, before relighting.

Concentric jets, where the oxygen is supplied by an interior tube to the middle of the flame, are inferior for use in lanterns, because they produce rather a ring of light on the lime, than a single spot. This inferiority is most manifest in the gas microscope and polariscope, where great precision in collecting and concentrating the rays is required. In the ordinary magic lantern it is less noticed, but even there shows itself in the greater consumption of gas required, to produce an equal effect of illumination.

(To be continued.)

(Continued from page 3 8)

LECTURES ON ELECTRICITY AND LIGHT.

Delivered before the Franklin Institute, by Prof. Henry Morton, Ph.D.

Since the publication of the portion of this abstract which appeared in the last number of this Journal, we have learned from Messrs. Queen & Co. that the use of the internally silvered glass globe, there described, was suggested to them by Prof. Robert E. Rogers, of this city.

Before leaving the subject of the development of electricity by friction, it remains for us to give some account of that which is known as the Steam Electrical Machine.

The development of this apparatus originated with an accidental discovery made by a workman who had charge of a steam-boiler at one of the collieries near Newcastle-on-Tyne, England. He found that when one of his hands was in the jet of steam which escaped from a small leak near the safety-valve, and the other hand was brought near the metal of the boiler, sparks would fly between the hand and boiler, and a series of shocks be at the same time experienced.

This experiment was repeated, varied and extended, by Mr. W. G. Armstrong, H. L. Pattinson and others, but for a long time the true cause of the phenomena was not understood. Even Faraday at first supposed it to be the action "already known, and by some ascribed to mere evaporation, by others to chemical action."

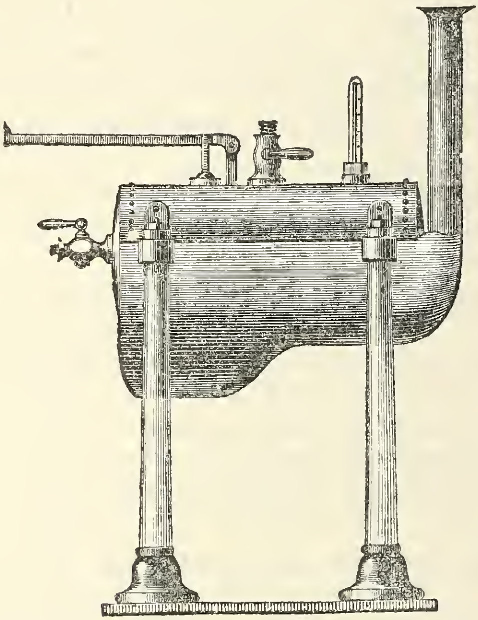
It was at last, however, found to result from the friction of particles of water carried out with the escaping steam, and rubbing against the material of the orifice. And it was shown by Mr. Armstrong, and since, in various ways, by others, that like effects may be produced with currents of air, and many gases, provided they are caused to carry spray of water with them as they escape.

The history of the first discovery and development of this subject will be found in the *Philosophical Magazine*, vol. xvii., pp. 370, 452; vol. xviii., pp. 50, 93, 95, 100, 328; vol. xix., pp. 25, 88; vol. xx., p. 5; vol. xxii., pp. 1, 486, 570; vol. xxiii., p. 194, and in the *Philosophical Transactions* for 1843, p. 17, where Faraday has given a very thorough discussion of the theory and experiments.

The apparatus required and heretofore used in the development of electricity in this manner, is very simple. A steam-boiler, internally

fired, is mounted on glass columns, (see Fig. 10,) by which means it is thoroughly insulated. This course is adopted because it is found better to employ that portion of the electricity developed in the boiler,

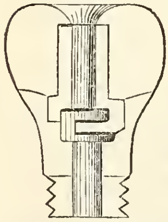
Fig. 10.



than the opposite kind produced in the escaping steam, and which can be less easily and thoroughly collected from points immersed therein.

This boiler is provided with a safety-valve and pressure-gauge, as indicated, and also with a large stop-cock in the centre above, to which is attached an horizontal pipe, carrying several nozzles of such a shape as represented in Fig. 11.

Fig. 11.



In this, the shaded portion in the middle represents the interior passage. The projection into this passage, near its lower part, causes the jet to pass into that immediately above, in a cup-like form, by which means a more violent friction, between the watery particles in the jet and the sides of the tubes, is secured. This interior portion should be of metal, the exterior, or cap, of wood.

(To be continued.)

Franklin Institute.

Proceedings of the Stated Monthly Meeting, April 17th, 1867.

The meeting was called to order with the President, Mr. J. V. Merrick, in the chair.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported that, at their stated meeting, held April 10th, inst., donations to the library were received from the Royal Astronomical Society, the Royal Geographical Society, the Royal Institution, the Society of Arts, and the Institution of Civil Engineers, London, England; l'Academie des Sciences, Paris, et la Société Industrielle Nationale, Mulhouse, France; the Geological Society, Quebec, and Maj. L. A. Huguet-Latour, Montreal, Canada; Rear Admiral C. H. Davis, Superintendent of the United States Naval Observatory, and from the Superintendent of the United States Coast Survey, Washington, D. C.; the Ohio Mechanics' Institute, Cincinnati, Ohio; Mercantile Library Company; Dr. T. S. Kirkbride, Prof. Henry Morton, Messrs. Charles McManus and A. J. Demoret, Philadelphia.

On motion of Prof. H. Morton, it was

Ordered, that a vote of thanks by the Board of Managers of the Franklin Institute be presented to James Swain, Esq., for his exertions in promoting the interests of the Institute.

The President read a letter from Maj.-Gen. G. G. Meade, asking the Franklin Institute to take action in regard to a monument to the memory of Prof. A. D. Bache.

On motion of Messrs. Fraley and Wm. Sellers, it was

Ordered, that the letter be referred to the Institute, with the recommendation that a committee be appointed to take action in the object proposed.

The various standing committees reported their minutes. The Special Committee on Experiments in Steam Expansion reported progress. The Special Committee appointed to prepare a memorial to Congress, with reference to the establishment of a uniform Code of Danger Signals, reported progress. The Special Committee on the preparation of a draft of ordinance to provide for the Inspection o Steam Engines and Boilers in the City of Philadelphia, reported their minutes.

The Secretary's report on Novelties in Science and the Mechanic Arts was then read. (An abstract of this will be found in the Editorial Department.)

The following remarks, suggested by statements in the Secretary's report, were then made by Mr. Robert Briggs:

Mr. Briggs. In regard to this particular case, referred to by the Secretary, I will state that we had, at the Pascal Iron Works, a bearing of the main shaft of one of our mill engines, which carried a load, not exceedingly heavy, only some one hundred and sixty pounds per square inch on the bearing surface; not more than proper to carry, but at the running velocity of forty-six revolutions, more than it could sustain without heating and rapidly wearing. After experiencing a great deal of trouble with it, putting in new boxes every three months as a regular thing, I removed the pedestal and put in a new one, in which the lower bearing was a hollow brass casting, through which a stream of water ran constantly, cooling it down to such a point that the lubricant used was not dissipated. By this means, we have been able to keep the box in perfect working condition without appreciable wear, while running night and day for about three years. I did not mention this to the Secretary as anything new, but only as an instance to show that the heat produced by the friction of the shaft upon the bearing was an important element, and that I did not think we would be justified in saying, without qualification, that there is any definite load to the square inch which a bearing should carry.

We find that surfaces covered with oil maintain their oily character and loss of friction with much reliability for years. Take, for instance, an ordinary screw bolt, which is the simplest and most commonly turned thing anywhere. Its velocity of turning is exceedingly small, the common load for the square inch of surface on the thread of the screw is from eleven to eighteen thousand pounds. Under that load per square inch of surface, a well oiled bolt, once oiled, remains so. At almost any time it can be turned backwards and forwards, and can be used constantly and regularly without any undue resistance beyond the ordinary loss of friction—following directly the law of friction—the resistance of turning increasing directly with the load per square inch of surface. I name this as being the strongest possible case of a shaft having the minimum of velocity and the maximum of pressure.

When we come to apply the same conditions to ordinary journal bearings, the same rules obtain. The English habit of proportioning

the bearings of shafts have been justified by the experience of many hundreds of mechanics, and are perfectly correct. Thus, it is an habitual thing for them to state that about once and a quarter the diameter of the shaft is abundantly long for the bearing. This law is correct if three conditions are complied with, viz: first, that the shaft shall be of cast iron where the diameter shall be exceedingly large as compared with its strength; second, that its velocity shall be low, which is the condition of all English shafting; thirdly, that many belts should not be used, belts producing heavy straining upon the surface of the bearings. Under these three conditions, the English rule is obviously correct in practice, and can hardly be impugned. We cannot apply the laws at present used in ordinary bearings for cotton machinery to propeller shafts, where the load to the square inch is light, and even where it is heavy on the main bearings of these shafts. We find we cannot increase the length without heating more seriously from the increase of length than we should have done by decrease of bearing surface. It has been a mistake with many eminent mechanics of exaggerating the length of the main bearings, and, as a result, finding they could not drive the engine. The proportions adopted in propeller engines serve as a very admirable guide for the proportions required under the circumstances, and they would be found, under examination, to show that the rate of velocity, as well as the weight, is to be taken into consideration.

Looking at the matter in a more theoretical manner, we see that the box has to carry a certain weight under a given velocity, and to maintain a certain friction, producing a definite amount of heat. If the movement of heat be not dissipated by the external surface of the box, it will go on accumulating until it reaches some point at which the lubricating material will cease to be a lubricant. Our oils change in character under an increased temperature. Sperm oil, up to 180° to 200°, is a very fair lubricant. On the contrary, lard oil, at 110°, ceases to be a lubricant at all; it flows freely from the sides of the box, leaving it comparatively stripped and naked, when an abrasion of material takes place with great rapidity, the box heats, and is gone. That which I want to state distinctly is, that the journal-box itself should, in some way, act in dissipating the heat generated by friction. For this reason, we find the weight of the box has some value.

If the shell of a bearing is too light, or is too isolated from contact with its pedestal, if it be set in wood or other non-conducting material, the chances are that, with a light load and with a low velocity, and

with careful lubrication with a good lubricant, it will heat excessively. On the other hand, a heavy shell well bedded in an iron frame, and exposed to the air, will disperse the heat of rotation or friction of a shaft, under unfavorable circumstances as regards load, or surface, or velocity.

So far as the materials which constitute bearings are concerned, those which are the hardest, and which will not abrade into angular fragments, are those best adapted for forming both shaft and box. It is important that the materials should be such as will run with the least amount of friction upon each other. Thus cast iron upon cast iron does not behave so well as wrought iron on itself or on cast iron. Wrought iron on cast iron is admirable, but the moment either the velocity or the load becomes excessive, brass is far superior to cast iron, because it is a so much better conductor of heat. Pressure cannot be taken as the sole basis of friction. We have four or five kinds of bearings. The condition of a shaft turning upon a point or end surface is altogether different from that of a shaft turning in a box, so far as the lubricant is concerned. In the former case, the oil, by its very rotation, is carried from the centre outwards. On this account, in all fast running, and in fact in all running of vertical spindles, it is better to arrange gutters which shall permit the oil to enter the centre and pass out on the outside, running the whole end in a box of oil, and thus pumping a fresh supply every moment. There are some anomalies in regard to bearings which it is nearly impossible to explain. Thus, a solid box has a permanency, certainly, as compared with any parted box, which cannot be accounted for.

I can hardly agree with the writer quoted by the Secretary, in the conclusions he has reached in regard to soft metals. The practice of all locomotive constructors is to use a brass box, perforated with holes and lined with soft metal, and I am not prepared to admit that that practice has not the warrantage of some reason. To be sure, some of the soft metals hold fragments of dust. But while this is the case with some, it is not true of all. Thus, lead, which is a tenacious metal, (each particle of fresh lead, as it leaves its bed or matrix, adhering upon a new or exposed surface anywhere, sticking in one mass readily,) is one of the most admirable materials for holding grit and sand; on the other hand, in zinc there is not the slightest tendency for abraded particles to re-adhere, nor does the metal form a lap to hold grit.

The metal known as Babbitt's is one of the best soft metals known.

This metal is composed of tin, zinc and antimony, is comparatively hard, unshrinking in cooling, and will not hold grit to any injurious extent.

Mr. Coleman Sellers said he would like to add a few words with reference to velocity and its effects. He instanced an experiment, made some years since, with a worm and worm-wheel hoisting machine. The machine had a constant and uniform load to hoist, viz: the weighed charges to the charging floor in an iron foundry. As first constructed and used, for a period of at least six years, hoisting at a given speed, and with the worm running at a given velocity, the engine driving the works was always slowed down by starting the hoister. In fact, there evidently was not power enough to work the machine successfully. A change was afterwards made in the machine, by increasing the size of the wire rope drum, to such an extent as to double the pressure on the worm and wheel, and therefore, to hoist at the same speed, the worm would have to revolve at one-half its former velocity. This change, and it only, so affected the running of the machine, that hoisting the same load at the same speed did not, in any case, have any noticeable effect on the speed of the engine.

In some experiments on screws, testing the principles on which they work, it was found a screw having one inch area, exactly, would work under seven thousand pounds to the square inch. It would probably have operated well to eleven thousand pounds, but the pressure actually applied was seven thousand pounds; while the pressure exerted to turn the screw should have raised a weight of nearly seventy thousand pounds instead of seven thousand. That is, the loss in friction was enormous.

In regard to the use of soft metals for bearings, for a number of years I had experience in a rolling mill, and was very much in favor of what was known as soft metal, in all its various forms. After that, for several years, I was engaged in the building of locomotives, and in brass boxes drilled holes, and filled them with soft metal. All the packing rings in cylinders were filled with soft metals. A great many engineers, however, have done away with this, using brass for boxes for journals and steel packing rings in the cylinder. The advantage in the use of the solid box has been one which has struck almost all engineers who have had any experience. There are examples, to which I could point, of solid boxes having been run for a great many years, in one case fifteen years, showing no appreciable wear under

severe work. Yet, the convenience of the split box, of course, necessitates its use in certain cases.

In regard to soft metals in rolling machines, I hope soon to have some very interesting information from the Superintendent of one of the largest rolling mills in the United States, in which soft metals have been used for many years, very advantageously.

Mr. William Sellers remarked, with reference to the length of bearings tried by Mr. Corliss and others, and reported as not having been found beneficial, or positively injurious, that the length of bearing may have been more apparent than real. This would be the case if no precautions were taken to allow the bearings to adjust themselves to the shaft. It is quite possible an increase of length in rigid bearings may prove detrimental, because the liability to bind upon the shaft will be increased with their length, but with bearings that adjust themselves to the shaft it is difficult, with our present knowledge of the laws of friction, to understand how an increase of length could prove injurious.

It may be interesting to state, with reference to vertical shafts, and the plan referred to by Mr. Briggs, of oiling them in the centre, that perhaps the first instance, certainly the first I know of, in which this plan was carried out, was in 1847, in a very large mill, in New England. The company had experienced a great deal of difficulty in running their upright shaft, at that time the largest in New England running at a high speed. I myself had gone to the mill, to put on a new step, upon the usual plan then in use, when, at the instance of Mr. William Mason, of Taunton, it was proposed to place a cast iron base-plate on foundations resting upon it, one of similar size, upon the shaft, making both very large, and so arranged that the oil could get up in the centre of the lower plate, and be distributed over the whole rubbing surfaces by groves on the revolving base, just as in a millstone. This plan was at that time very successful, and I have used it many times in my own practice since, with equally good results.

One reason why the solid box may be better than the split one, would support Mr. Briggs' view, and that is, the solid box will carry off the heat generated better than the split one.

Mr. Briggs. I cannot go back much further than 1845, '46 and '47, about which time I had cognizance of the difficulty mentioned by Mr. Sellers, and the remedy employed. But my own impression is, that it is a device known to old millwrights, who used many ver-

tical spindles. I cannot imagine that they did not overcome the difficulty which they must have encountered in the manner mentioned.

Mr. Coleman Sellers said: Oliver Evans, in his *Millwright's Guide*, mentions the necessity of getting heat away from journals, and shows that when the gudgeons of water-wheels are not properly arranged to carry heat away, it will act very injuriously.

Mr. Briggs. The first time I ever saw the great exaggeration of bearing so much used in America, was in some machinery erected by Thomas Hill, where the main line of shafting was run at a speed of two hundred and forty revolutions per minute. In that case, the length of bearings were five or six times the diameter of the shaft.

Mr. William Sellers. It is possible, as Mr. Briggs suggests, that the kind of step I referred to as having been originated by Mr. Mason, may have been used by some of the older millwrights, but we always find that expedients are devised whenever the necessity for them is discovered, and I doubt whether any of the older millwrights had any such necessity; therefore, I doubt the device having been employed by them. Their upright shafts almost always ran very slowly, and there are no records of any such step having been used by them.

[Report No. 805.]

Committee on Science and the Arts.

ON THE CENTRIFUGAL GOVERNOR.

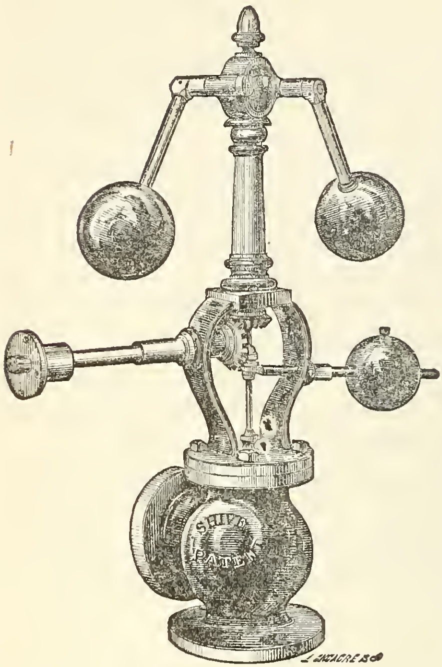
Invented by David Shive, Esq.

The Committee on Science and the Arts, constituted by the Franklin Institute of the State of Pennsylvania, for the promotion of the Mechanic Arts, to whom was referred for examination the improvement in Centrifugal Governors invented by David Shive, of the City of Philadelphia,

Report, That the improvement above named consists in so suspending the arms or rods carrying the heavy balls, that they shall be free to move in a plane which occupies a position intermediate between one tangent and one radial to the circle of motion.

The advantages which it is proposed to secure by this means are as follows: Greater sensitiveness to slight changes of velocity, and a more prompt action as a result of this than can be secured by the ordinary form of governor in which the arms move radially, or in any other form heretofore employed. The reason of this superior efficiency in the points enumerated is stated as follows: Any change

in velocity must act initially in a tangential direction; hence, looking at this point alone, if the arms were supported by joints allowing a tangential motion, they would be in the best possible position for allowing the change in relative velocities of the supporting joint and ball to cause a change in inclination of the connecting-rod, which is the means of operating the valve. For in this case the change would act at once in the plane of motion allowed by the joint, and would experience no resistance by binding or jamming of the joint or guide.



If, however, the motion allowed by the joint were (as is usual) in a radial direction, then the first effect of a change of velocity would be to produce a pressure against the joint, and the outward or inward motion of the rods and balls would only occur as a secondary action or resultant of this resistance in the joint and the change of relative velocity. From these considerations it might appear that, regarding the change of velocity only, the best position of the joint would be that which allowed a tangential motion. Such would indeed be the case if the normal condition of the governor were of rest, and it simply started forward or backward with changes of velocity. But the rotary movement of the governor when in use develops a centrifugal force which would cause a constant strain or binding in the tangential joint, and for this reason it is found best to give the joint such a position that it will allow of a motion exactly half way between the radial and tangential direction.

In the opinion of the Committee, the governor for steam engines above described is ingenious in its arrangement and thoroughly efficient in its operation, giving far greater delicacy at low velocities than any other form of governor heretofore constructed, and being for this reason of decided practical value. This form is, moreover, as simple

in its parts, and as cheap in its construction, as that commonly employed.

By order of the Committee:

WILLIAM HAMILTON, *Actuary*.

Sub-committee of Examination: Washington Jones, S. Lloyd Wiegand, Emile Geyelin, Robert H. Lamborn.

Philadelphia, January 19th, 1867.

Bibliographical Notice.

THE ART OF PERFUMERY, and the Methods of Obtaining the Odors of Plants, &c., &c, with an appendix on preparing Artificial Fruit, Essences, &c. By G. W. Septimus Piesse. Second American, from the third London edition. Lindsay & Blakiston, Philadelphia, 1867.

The above work may be regarded as a hand-book and dictionary for the practical perfumer, offering him a vast amount of information as to the source and preparation of his ingredients, and many receipts and directions for their judicious combination; together with a theoretical discussion on odors and perfumery in general, by way of an introduction. With regard to this theoretical portion, we think that little can be said in commendation, though this, perhaps, is less the fault of the author than of the subject. About the cause of smell we know next to nothing; theorizing is therefore dangerous, because unguided. The particular theory here discussed and advocated, is that of an analogy between odor and music, similar to that which exists between light and sound. This is peculiarly unfortunate, for the little knowledge which we *do* possess as to odor, points in quite another direction. Heat, light and sound are all affections, or strictly, *motions* of matter, all and any of which, in all their individual variations, may exist in the same body in succession, without necessity of change in its material. Thus an iron wire may vibrate in succession a thousand different notes, may then emit a thousand various temperatures, and may, lastly, be caused to radiate every sort of light, and yet be nothing but an iron wire from beginning to end; but where is the body that will, unchanged, give us more than one perfume? The reason is clear. Perfume is not the result of a motion, which any mass of matter may assume, but the consequence of some special property, some peculiar form and arrangement of atoms (we know not what) which belongs in each case to a special substance, and cannot

be transferred to or from another. To arrange "smells," therefore, on a musical scale is a mere matter of fanciful and far-fetched analogy, without the shadow of a support in scientific fact. Far worse is it to confuse known actions with assumed nonentities, and to compare the mutual absorption of volatile acids and alkalies (which, becoming solid, in place of being gaseous, fail for *this* reason to affect the sense of smell) with the phenomena of "interference" in light and sound.

These theories, we are happy to say, however, occupy but a small space in the present work, and whatever is deficient in them is largely made up in the subsequent portions, which are filled with exactly what those purchasing such a book would look for and expect to find: facts and not fancies, statistics, not similies. We first find, in alphabetical order, full descriptions of all the perfume yielding substances, and their mode of preparation, embodying the various improvements which have been made in this direction, of late years. We have then, directions for the manufacture of smelling salts, perfumes, essences, soaps, cosmetics, oils, &c., &c., with every detail. Among these we notice some novelties, which are curious. Thus, at page 340, we read of a cosmetic which, rubbed upon the cheek or lips, though colorless at first, gradually turns to a deep rose color, from the action of the air. Among many other valuable suggestions, we note the following, on page 363. Sponge can decompose soap and clog itself with the grease. When rendered useless by this means, it may be cleaned by soaking for twenty-four hours in a lye of soda, and after rinsing and a second washing in water with a little muriatic acid, will be restored to perfect condition. Of the typography and binding we cannot speak too highly. It is everything that the most fastidious author or reader could ask. It is, indeed, such as would do credit to a merely ornamental publication.

WILL'S TABLES FOR QUALITATIVE ANALYSIS. Translated by Prof. Charles F. Himes, Ph.D., of Dickinson College, Carlisle, Penna.: Henry C. Baird.

THERE are some books, like some men, whom "to name is to praise;" and, moreover, in both cases, the extent of the fame and the simple *goodness* of the subject, sometimes makes the duty of the critic far from easy. Everybody knows the great and good man. How shall we rehearse his virtues and not be trite, especially if his goodness has kept him out of mischief and exciting incidents? Somewhat

such as this is our embarrassment in the present case. Will's Tables are used almost universally in the Chemical Schools of Germany, and thus most of our chemical readers will know, directly or indirectly, already, all we could say in their praise. Then, being thoroughly good chemical tables, we can make no entertaining discussion on their assumptions and their theories; for, knowing the duties of good tables to require eschewing of theories, &c., they have all such things accordingly eschewed.

To every student of analytical chemistry, however, young or old, and to every instructor in this branch, we can say, Will's Tables have been admirably put into English by Dr. Himes, and are published by Mr. Baird, who, we hope, will be able to fill the orders, which will come in when this fact is known, as fast as they will arrive.

THE ART OF MANUFACTURING SOAP AND CANDLES. Including the recent discoveries, &c., &c., and the making of Tallow and Composite Candles. By Adolph Ott, Ph.D. Lindsay & Blakiston, Philadelphia, 1867.

From another publication, bearing the name of Dr. Ott, we see that he comes to this country from the University of Turin, and we have thus explained to us certain peculiarities in the use of words, or liberties taken with the etymology of our language, which we may allow in courtesy to a foreigner, though we should take exception to the same at the hands of a countryman.

Making this little allowance, however, we shall find this work very clearly and pleasantly expressed, aud rich with much new material not before offered to the reader in any collected form. The last improvements and patents in the branch of manufacture treated, are clearly and yet briefly stated, and many good wood cuts assist the explanations. One point we notice which needs filling up. It is stated that soda is prepared in *Europe* from cryolite. Our author is not, perhaps, aware that the Pennsylvania Salt and Alkali Company are importing and manufacturing six thousand tons, annually, in this country. There are many points of interest connected with this same manufacture, important to soap boilers, which we have not space here to relate.

A COMPARISON *of some of the Meteorological Phenomena of* APRIL, 1867, *with those of* APRIL, 1866, *and of the same month for* SIXTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11¼′ W. from Greenwich. By PROFESSOR J. A. KIRKPATRICK, of the Central High School.

	April, 1867.	April, 1866.	April, for 16 years.
Thermometer—Highest—degree	80·00°	82·00°	88·00°
" date	22d.	21st.	24th, '61.
Warmest day—mean	64·83	73·17	74·30
" " date	22d.	21st.	29th, '56.
Lowest—degree	36·00	37·00	20·00
" date	28th.	8th.	7th, '57.
Coldest day—mean	41·50	38·67	27·70
" " date	24th.	8th.	2d, '57.
Mean daily oscillation	17·75	14·17	16·40
" " range	6·54	6·09	6·23
Means at 7 A. M.	47·22	50·30	46·22
" 2 P. M.	59·92	61·28	57·86
" 9 P. M.	52·32	54·80	50·09
" for the month	53·15	55·46	51·39
Barometer—Highest—inches	30·314	30·252	30·518
" date	14th.	17th.	3d, '54.
Greatest mean daily pressure	30·289	30·203	30·458
" " " date	14th.	17th.	3d, '54.
Lowest—inches	29·295	28·820	28·820
" date	22d.	23d.	23d, '66.
Least mean daily pressure	29·516	29·051	28·959
" " " date	22d.	23d.	21st, '52.
Mean daily range	0·234	0·145	0·171
Means at 7 A. M	29·966	29·832	29·830
" 2 P. M	29·906	29·771	29·786
" 9 P. M	29·931	29·800	29·817
" for the month	29·934	29·801	29·811
Force of Vapor—Greatest—inches	0·504	0·605	0·689
" date	30th.	21st.	29th, '65.
Least—inches	·074	·094	·066
" date	6th.	9th.	13th, '52.
Means at 7 A. M	·213	·266	·233
" 2 P. M	·222	·302	·249
" 9 P. M	·241	·305	·253
" for the month	·225	·292	·245
Relative Humidity—Greatest—per cent	94·0	90·0	100·0
" date	30th.	19th.	Often.
Least—per cent	21·0	18·0	13·0
" date	6th.	29th.	13th, '52.
Means at 7 A. M.	63·0	69·2	70·5
" 2 P. M.	42·6	51·9	50·9
" 9 P. M.	59·3	67·1	66·8
" for the month	55·0	62·7	62·7
Clouds—Number of clear days*	9·	7·	8·4
" cloudy days	21·	23·	21·6
Means of sky covered at 7 A. M	58·0 per ct	67·3 per ct	62·7 per ct
" " " 2 P. M	57·7	71·3	66·1
" " " 9 P. M	42·3	54·3	52·8
" " for the month	52·6	64·3	60·5
Rain—Amount—inches	1·360	2·922	4·479
No. of days on which rain fell	10·	10·	12·6
Prevailing Winds—Times in 1000	S 80° 8′ W·143	N 74°45′ W·141	N 68°47′ W·147

* Sky one-third or less covered at the hours of observation.